Foreword

The "Educational Guide to Covered Bridges in the United States" consists of a printed guide, with 10 units and a bibliography, and a companion interactive CD-ROM. This project is one of several funded by the Federal Highway Administration under the National Historic Covered Bridge Preservation Program.

The objective of this project was to produce an educational guide on the history and preservation of covered bridges in the United States that is suitable for use by teachers of grade levels from kindergarten through the senior year in high school. It is hoped that this guide will stimulate the students' interest and understanding of the basic "nuts and bolts" engineering aspects of covered bridges, as well as illuminate the place of the covered bridge in transportation history and in the development of U.S. bridge design technology. The discussion of current bridge restoration projects around the country will help students comprehend the basic philosophy and techniques of covered bridge restoration and preservation.

This educational guide has been produced by West Virginia University's Institute for the History of Technology and Industrial Archeology, under the leadership of Dr. Emory Kemp, Director Emeritus of the Institute, a well-known bridge historian. The primary users of this guide will be history teachers; however, mathematics, science (physics), and English teachers may find certain units useful in their classes. While the general grades and subjects for each unit are indicated in the guide, teachers will want to use their discretion as to which units are suitable for their classes.

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Unit One: The Covered Bridge as a Symbol of 19^{th} Century America	
Lesson One: Why Were Covered Bridges Covered?	**Grade Level: All**

Learner Objectives

Students will identify the important place of the covered bridge in American history and understand the practical reasons why it was covered. Students will learn how covered bridges were used for a variety of purposes besides transportation.

Common Core and National Education Standards

- Reading Standards for Informational Text:
  - *RI.K-12.7* – Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. (Activities 1 and 3)
- Writing Standards:
  - *W.4-5.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 3)
  - *W.K-5.3* – Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences. (Activity 2)
- Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects:
  - *WHST.6-12.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 3)
  - *WHST.6-12.3* – Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences. (Activity 2)
  - *WHST.6-12.4* – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Activity 3)
  - *WHST.6-12.7* – Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (Activity 3)
  - *WHST.6-12.8* – Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. (Activity 3)
- Speaking and Listening Standards:
  - *SL.K-12.1* – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (Activity 1)
- Technology:
  - *NT.K-12.5 – Technology Research Tools* – Students use technology to locate, evaluate, and collect information from a variety of sources; students use technology tools to process data and report results; students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks. (Activities 2 and 3)

Duration

Elementary grades – one 45- to 50-minute class period
Secondary grades – two or three 45- to 50-minute class periods

Materials
✓ Mythical Explanations for Covering Bridges Handout ✓ London Bridge Handout ✓ PC with word processing and internet ✓ Covered Bridges CD-ROM ✓ Vocabulary List

Activity 1 – Notes and Discussion

- Show the students a few pictures of covered bridges, found in the K-2 section of the CD-ROM.

- For K-3 students:
    - Have the students put their heads down while the teacher turns out the lights and asks them to imagine that they lived long ago. They live in a time with no cars, no television, and no radio. They had to ride horses to get from place to place. As they come upon a stream, they must now cross the covered bridge.
    - Ask the students to describe what they hear, what they see, what they smell, etc. Also ask them to imagine what a covered bridge would be like to cross at night.
    - Introduce the topic with the Teacher's Notes and discussion questions.

- For fourth grade and up:
    - Have the students form groups of three or four. Have the students generate a description of one of the pictures, physical and emotional, and concrete and abstract, describing both what they see and what they feel.
    - Introduce the topic with the following Teacher's Notes and discussion questions, "Why Were Covered Bridges Covered?"

Why Were Covered Bridges Covered?

Teacher Notes & Discussion

The American covered bridge is a charming legacy left over from the days of horse-and-buggy and barnyard dances in the 19th century. It is the symbol of a simpler time without email, fast-food restaurants, and satellite television. Obviously, the most distinguishing characteristic of a covered bridge is its roof, making the bridges resemble little barns spanning a river or stream.

- Ask: Why do you think these bridges are covered?
- For fourth grade and up:
    - Pass out the handout titled "Why Were Covered Bridges Covered? Mythical Explanations." Have students read these myths aloud and circle reasonable or unreasonable on handout. Discuss some of these explanations and ask students why they would not be correct. Allow students to defend their answers. (Note: Some of these explanations were silly.)
    - Return to the following notes and discussion.

Covered bridges were actually covered to protect the wooden skeleton (the **truss** and the deck) from rotting. Bridges were covered for **preservation –** a wooden bridge that was uncovered would last only about 5 years, but adding a roof would extend its life indefinitely.

Covered bridges were a great place for children to play. Children could swing from the **rafters** like Tarzan, hand over hand from beam to beam. They could hide in the rafters and play practical jokes on people as they walked or drove their buggy through. If the children grew bored with playing, they could always read the **graffiti** written on the bridge walls. Perhaps people kept up on town gossip this way.

Covered bridges could also be scary places, especially at night. Many of them did not have windows to let in the moonlight, so they were often pitch black at night. It was very easy for a lone traveler to imagine a robber hiding in the rafters above, waiting to pounce on his wagon and take whatever they please, possibly his life! Charles Dickens once made note of this fear in his *American Notes*.

Covered bridges also acted as what we would call billboards today. **Advertisements** were painted or nailed directly onto the siding of the bridges, inside and out. These signs advertised everything from medicines and cooking utensils to personal services. Another common adornment on a covered bridge was a warning against driving horses too fast across the bridge. This warning usually appeared outside of the bridge on the **portal**. It read:

“FIVE DOLLAR FINE FOR RIDING OR DRIVING
ON THE BRIDGE FASTER THAN A WALK.”

There was a good reason to have this sign – the simultaneous beat of horse hooves galloping across the bridge could damage the joints of the bridge.

Covered bridges gained a romantic appeal in their heyday, as well. They were often known as “kissing bridges.” The bridges tended to be dark, even more so at night, and resembled a tunnel of love. Many young couples would drive into the bridge and steal kisses and sneak hugs – this is when practical jokers hiding in the rafters would have the most fun.

These bridges also sheltered many different kinds of meetings. Before the days of air conditioning they were great places for church meetings and dinners on a hot day. They sheltered political rallies and bond rallies during World War II. Some people even hung their laundry up to dry in covered bridges. Drivers would also tie their horses up inside the bridges while they made a quick trip into the general store.

Activity 2 – Creative Writing

- Show the students the photos of the covered bridges from the CD-ROM again.

- For K-3 students:
  - Let them think of their own stories based on the emotions and memories they experience when looking at the picture. Students can draw a picture based on the story they are thinking about and then describe the picture.
  - After examining the pictures of the covered bridges, ask students to recall what shapes are associated with them. Ask: Why do you suppose these shapes are used? Students can then go on to create these shapes on their drawings using popsicle sticks, toothpicks, or other materials for *members*.

- For fourth grade and up:
  - Let them write their own stories based on the emotions and memories they experience when looking at the picture. Allow those who are willing to share their stories with the class.

Activity 3 – Reports

- For fourth grade and up:
  - Have students divide into groups of three or four (or whatever is appropriate) and research any covered bridge in the United States. They can gather facts, interesting stories, preservation information, and so on. They will search the internet, use the school library, or the CD-ROM. Have the students then write a report, utilizing a computer, based on their findings. Finally, have each group give a presentation on their chosen bridge to the class.

Enrichment Activity:

- For third grade and up:
  - If possible, plan a field trip to a covered bridge located near your school. Use the resources on the CD-ROM to obtain facts about the bridge, along with any interesting stories concerning the bridge. You may also want to contact local covered bridge societies to see if they offer any pre- and post-field trip information regarding your chosen bridge.

- For K-2 students:
  - Incorporate the classic children's game "London Bridge is Falling Down" to introduce some of the myths about bridges in general (that they needed a human "protector" or "watcher" to keep them standing). One obscure verse of this rhyme includes a watchman for the bridge. Possibilities include role-playing – one student plays the watcher of the bridge while two others join hands to form the bridge and the rest of the class goes under it. Whomever the bridge lands on at the end of the verse gets to be the next "watcher".

Name: ______________________________

WHY WERE COVERED BRIDGES COVERED?
MYTHICAL EXPLANATIONS

1) Bridges were covered to protect travelers, their horses, and their **cargos** from bad weather, such as rain or snow.

REASONABLE OR UNREASONABLE

2) Bridges were covered so that horses, as well as other livestock, would not be afraid to enter them (horses and cows sometimes “spook” or become frightened when crossing open bridges). With a covered bridge, horses thought they were simply entering a barn.

REASONABLE OR UNREASONABLE

3) Bridges were covered so that they would be more attractive.

REASONABLE OR UNREASONABLE

4) Bridges were covered so that there would be a place for advertising.

REASONABLE OR UNREASONABLE

5) Bridges were covered to prevent horses from shying at the sight of water.

REASONABLE OR UNREASONABLE

6) Covered bridges were built by people who first constructed barns, and that is all they knew how to build.

REASONABLE OR UNREASONABLE

7) Bridges were covered to prevent lightning from striking them, a common problem with iron bridges.

REASONABLE OR UNREASONABLE

8) Bridges were covered to keep snow off the floor.

REASONABLE OR UNREASONABLE

9) Bridges were covered to prevent the traveler from seeing the town ahead and turning back if they did not like it.

REASONABLE OR UNREASONABLE

10) Bridges were covered for protection from the Indians.

REASONABLE OR UNREASONABLE

LONDON BRIDGE IS FALLING DOWN
INSTRUCTIONS AND LYRICS

1. Choose two children to create an arch. Have them face each other, join both hands together and lift their arms up.
2. Line up the other children so they can walk under the arch.
3. Begin singing, "London Bridge is falling down, falling down, falling down, London Bridge is falling down, my fair lady."
4. Walk the line of children under the arch and back around, creating a circle of children consistently walking under the arch.
5. Instruct the two children who are the arch to drop their hands down on the last word of the rhyme, trying to capture a child between their arms.
6. Repeat these actions with each verse of the rhyme until all the children are captured.

London Bridge is broken down,
Falling down, falling down.
London Bridge is falling down,
My fair lady.

Build it up with wood and clay,
Wood and clay, wood and clay,
Build it up with wood and clay,
My fair lady.

Wood and clay will wash away,
Wash away, wash away,
Wood and clay will wash away,
My fair lady.

Build it up with bricks and mortar,
Bricks and mortar, bricks and mortar,
Build it up with bricks and mortar,
My fair lady.

Bricks and mortar will not stay,
Will not stay, will not stay,
Bricks and mortar will not stay,
My fair lady.

Build it up with iron and steel,
Iron and steel, iron and steel,
Build it up with iron and steel,
My fair lady.

Iron and steel will bend and bow,
Bend and bow, bend and bow,
Iron and steel will bend and bow,
My fair lady.

Build it up with silver and gold,
Silver and gold, silver and gold,
Build it up with silver and gold,
My fair lady.

Silver and gold will be stolen away,
Stolen away, stolen away,
Silver and gold will be stolen away,
My fair lady.

Set a man to watch all night,
Watch all night, watch all night,
Set a man to watch all night,
My fair lady.

Unit One Vocabulary	
Advertisements	A paid announcement, as of goods for sale, in newspapers, magazines, billboards, on radio or television, etc.
Cargo	The load of goods carried by a ship, airplane, truck, horse and cart/buggy, etc.; freight
Graffiti	Markings, as initials, slogans, or drawings that are sketched on a sidewalk, wall, or other public place.
Member	A part of a whole. An individual angle, beam, or built piece intended to become an integral part of an assembled frame or structure.
Portal	A door, gate, or entrance, especially one of imposing size and appearance. On a bridge it is the clear unobstructed space forming the entrance to the structure. An iron, steel, or timber frame for bracing the end of a bridge. It is in the plane of the end posts (diagonals) and usually has curved or sloping knee braces between the end post and the horizontal strut that runs across the top. While the portal strut is usually a truss, it could also be a stiff built-up beam section.
Preservation	The process of working to protect something so that is not damaged or destroyed.
Rafter	Any of a series of beams or the like, usually having a pronounced slope, for supporting the sheathing and covering of a roof.
Truss	An open structural framework with triangular panels designed to function as a large beam.

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<tr><th>Lesson Two: Covered Bridges in Literature</th><th>Grade Level: 9-12</th></tr>
<tr><td colspan="2">Learner Objectives</td></tr>
<tr><td colspan="2">Students will learn of the romantic and nostalgic symbolism of covered bridges as presented within the context of literature. Students will also determine the symbolism of covered bridges throughout different eras in American history.</td></tr>
<tr><td colspan="2">Common Core Standards</td></tr>
<tr><td colspan="2">♦ Reading Standards for Literacy in History/Social Studies:
o RH.6-12.1 – Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. (Activity 1)
o RH.6-12.3 – Analyze how and why individuals, events, or ideas develop and interact over the course of a text. (Activity 1)
o RH.6-12.9 – Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take. (Activity 1)
o RH.6-12.10 – Read and comprehend complex literary and informational texts independently and proficiently. (Activity 1)
♦ Speaking and Listening Standards:
o SL.6-12.1 – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (Activity 1)
o SL.6-12.4 – Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience. (Activity 1)</td></tr>
<tr><td colspan="2">Duration</td></tr>
<tr><td colspan="2">Secondary grades – two 45- to 50-minute class periods</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">✓ American Notes by Charles Dickens (especially chapters 9 and 10)
✓ John Brown's Body, Book One by Stephen Vincent Benet
✓ The Bridges of Madison County by Robert James Waller</td></tr>
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Activity 1 – Notes and Discussion

- Prior to the discussion, students should be broken into three groups, and each group assigned one of the texts to read.
- Introduce the topics with the following Teacher's Notes. Discussion questions can be posed to each group of students in a panel format.

Covered Bridges in Literature

Teacher's Notes and Discussion:

The following literature concerns the symbolism of covered bridges in American culture today and in times past. The authors mentioned have varying ideas as to the importance of these bridges throughout American history.

American Notes by Charles Dickens

Covered bridges are not often mentioned in *American Notes*. However, there are two references in two different chapters: Chapter 9 – "A Night Steamer on the Potomac River," and Chapter 10 – "The Canal Boat." (If time is of the essence, you may want to concentrate only on these chapters. However, this book is a fine example of the genre of travel literature.) *American Notes* conveys a personal feeling of time and place in the areas the author visited, instead of mere history alone. Applied to American culture, the text is priceless because it provides a faceted array of observations during America's infancy.

The covered bridge crossed by Dickens in Harrisburg, PA was built by Theodore Burr. It was a Burr-Arch-Truss design (the most numerous bridge truss type of those surviving today) and was nicknamed "Old Camelback" by inhabitants. The bridge lasted until 1903 when it was destroyed by a flood. The bridge in Pittsburgh, PA, was a covered wooden canal aqueduct built in 1836. This bridge carried the Pennsylvania Canal over the Allegheny River. It was estimated that the aqueduct bridge carried 2,000 tons of water at a time. It was destroyed by pack ice in the Allegheny River in about 1842.

- Ask students to compare the negative way in which Dickens, a foreigner, describes covered bridges to the romantic notions Americans hold concerning covered bridges. Have them formulate some possible reasons why Dickens may have disliked the covered bridges. Was it because they had a distinctly American feel to them? Possibly he still harbored ill-will towards America and its institutions due to the Revolutionary War 60 years earlier and the War of 1812 only 30 years earlier.
- If your school is located in one of the areas covered in *American Notes*, ask students: how did a foreigner view their hometown more than 150 years ago? How does Dickens' description of their area compare to what the area is like today?
- **For Enrichment:** Have students examine Dickens' handling of bridges comprehensively. In order to do this, students must read the entire text. The types of bridges vary with the different modes of transportation that Dickens employs. Note: If you are interested in

covering American culture in general, this work is an excellent example of an outsider's view of 19th-century America.

- Have students discuss Dickens' views concerning the nation's new capital, Washington, D.C., plus New York City, Niagara Falls, the institution of slavery, covered bridges, and even Americans in general.
- Ask: How does he compare them to England and other places? How have they changed over time? How does he compare Englishmen's varying mannerisms, habits, beliefs, dialects, lifestyles, and institutions to those of Americans?

John Brown's Body, Book I by Stephen Vincent Benet:

Benet's poem begins with John Brown's raid. Benet believed that the raid was the precursor to the American Civil War, functioning, in essence, as the beginning of an end. In the poem, the bridge is a constant scene of violence, which may play into Benet's idea of the beginning of an end. People were dying, in this instance, because of slavery.

- Ask: What can the covered bridge symbolize in this epic poem? (Covered Bridges, as with tunnels, may be seen as sort of a corridor that changes people. Trouble surrounds them as they enter, but inside a transformation occurs which leads to their exiting as better people or learning valuable lessons. Perhaps such a transformation occurred in this story.) Note: John Brown entered the Potomac River covered bridge as an instigator of violence – a slave rebellion – but exited as a great martyr, a hero to Northern abolitionists.
- **For Enrichment:** Ask: What was the importance of the Potomac River covered bridge during John Brown's raid? (Brown's men occupied the bridge because it was the best get-away route to Maryland. It was also the scene of the first fatality of the raid – ironically that of Shepherd Heyward, a free black.)

The Bridges of Madison County by Robert James Waller:

This book is the epitome of covered bridge romanticism. Along with a contemporary view of covered bridges in the 1960s, the students will also experience a slice of rural Midwestern life. This part of the country is well known for its Hogsback Town Lattice covered bridges and these bridges seem to automatically be a part of the Midwestern landscape. The Bridges of Madison County wraps itself in the romanticism of covered bridges so tightly that readers can almost taste the sweet air surrounding the farmhouses, smell the hay and manure in the old barns, and hear the old farm truck rattle and bump against the wooden planks of the nearest covered bridge. Madison County, which is in Iowa, has many beautiful covered bridges but only two of them are important here: Roseman and Cedar Bridge. This novel is a love story between the characters Robert and Francesca. The bridges play a key part in the story, especially during romantic moments – a first encounter, a first date, and even a burial ground. Ask students to point out the key roles the bridges play in these particular moments.

- Ask: What do these bridges symbolize?
- Ask: What contemporary view does Waller give us of covered bridges in the 1960s, however short a glimpse? (The majority of the American public was not particularly concerned with covered bridges at this time. However, the story does mention the beginning of an interest to preserve the bridges in Madison County. Perhaps Robert is there on behalf of those early interests.)
- **For Enrichment:** Waller's work here includes other aspects of American culture that may also be discussed in class. The topic of morals is very crucial to this story. Ask: Have American morals changed significantly since the 1960s?

Unit Two: Bridge Building in Ancient and Medieval Times	
Lesson One: What Types of Bridges Came Before Covered Bridges?	**Grade Level: All**

Learner Objectives

Students will understand that bridge building is an activity that developed over time. Students will learn how bridge building technologies were developed through study within the context of the development of world civilization.

National Education Standards

- Social Science:
  - *Geography*
    - *NSS-G.K-12.1 - The World in Spatial Terms* – Students understand how to use mental maps to organize information about people, places, and environments in a spatial context. (Activity 1)
    - *NSS-G.K-12.2 - Places and Regions* – Students understand the physical and human characteristics of places. (Activities 1 and 2)
    - *NSS-G.K-12.5 - Environment and Society* – Students understand how human actions modify the physical environment; understand how physical systems affect human systems. (Activities 1 and 2)
    - *NSS-G.K-12.6 - The Uses of Geography* – Students understand how to apply geography to interpret the past. (Activities 1 and 2)
  - *World History*
    - *NSS-WH.5-12.2 - Era 2: Early Civilization and the Emergence of Pastoral People, 4000 - 1000 BCE* – Students understand the major characteristics of civilization and how civilizations emerged in Mesopotamia, Egypt, and the Indus Valley. (Activity 1)
    - *NSS-WH.5-12.3 - Era 3: Classical Traditions, Major Religions, and Giant Empires, 1000 BCE - 300 CE* – Students understand innovation and change from 1000-600 BCE: horses, ships, iron; and students understand the emergence of Aegean civilization and how interrelations developed among people of the eastern Mediterranean and Southwest Asia, 600-200 BCE. (Activity 1)
  - *Economics*
    - *NSS-EC.K-4.16 - Role of Government* – Students understand how governments provide certain kinds of goods and services in a market economy; students understand how governments pay for the goods and services they use by taxing or borrowing from the people. (Activity 1)
- Science:
  - *NS.K-12.1 - Science as Inquiry* – Students develop abilities necessary to do scientific inquiry and understanding about scientific inquiry. (Activity 3)
  - *NS.K-4.7 - History and Nature of Science* – Students understand science as a human endeavor. (Activity 1)
  - *NS.9-12.6 - Personal and Social Perspectives* – Students understand populations, resources, and environments; science and technology in society; risks and benefits; science and technology in local, national, and global challenges. (Activity 1)

Duration

All grades – two or three 45-minute class periods, depending on activities chosen

Materials
✓ Handouts of the Teacher Notes for student reference material ✓ Wooden blocks ✓ Popsicle sticks ✓ Lego blocks ✓ String, twine ✓ Tape ✓ Rulers ✓ Vocabulary list ✓ Crossword puzzle ✓ *Bridges* by Corbett ✓ *The World Building the Bridge* by Curren ✓ *Bridges and How They are Built* by Goldwater ✓ *The Art of Construction* by Salvador

Activity 1 – Notes and Discussion

- Ask: What would life be like in your community or state if all its bridges were removed in a single day? (Possible Answers: Many people would be unable to travel to work, the flow of goods and information would come to a halt, and so on.)
- The attached Teacher Notes would make a valuable handout for older students to read and later use as a reference when writing a paper on how bridges have altered economies, society and culture.
- Begin lecture using the Teacher Notes.

What Types of Bridges Came Before Covered Bridges?

Without bridges, life as we know it would be impossible. Transportation, communication, and trade all depend on these passageways. Bridges make it possible for people, information, and freight to move across rivers, canyons and other obstacles. Bridges are essential to modern civilization. However, mankind has never known a world without bridges of some sort. Although we know little about bridge building or construction in general before the dawn of the first civilizations, it is highly likely that prehistoric people used natural bridges, and eventually built crude bridges themselves. Most were nomads who wandered from place to place in pursuit of wild game. In their travels, they were bound to find streams they could not ford. Perhaps they found a tree that had fallen naturally across a stream from bank to bank and realized that it could be used for crossing. Eventually, humans learned how to chop down a tree themselves with stone tools and make it fall across the stream. By crossing the stream on this crude natural beam, humans had invented the bridge.

This primitive style of bridge is known as a **plank or beam bridge**. It is composed of two major parts. The beam or plank is the horizontal structural member – in this case, the log that connects the two sides of the riverbank. A beam may be made of wood or modern materials such as steel or concrete. The length of the beam from one side of the riverbank to the other is known as the span. The second part of a beam bridge is the **abutment** upon which the beam rests. The abutment may be composed of a variety of materials as well: earth, stone, steel, or concrete. Both parts of the bridge must be strong enough to support the weight of the people and goods that pass over them.

When the stream was too wide for a simple plank or beam span, a second span was added. Originally, a location where there was a large rock or small island in the middle of the river was selected. Later, people learned to build a support of stone or logs in the middle of a stream to support the ends of two separate planks; this is called a man-made **pier**. In this manner, the multi-span beam bridge was invented.

Another type of bridge developed before the dawn of civilization was the **suspension** bridge. The first of these was probably built in warm, wet climates where vines were plentiful and streams ran through deep canyons. Vines were woven together to form strong thick ropes known as cables. Then a pair of cables thick enough to support the weight of people and pack animals was carried across the canyon. These cables were laid out parallel to one another and pulled tight, then tied to anchors on each side of the canyon. The anchors, which were pulled inward when the bridge was in use, also had to be strong enough to support the weight of the load. Usually large trees growing along the edge of the canyon served as anchors. Branches and saplings were then laid across the cables and lashed to them with vines to provide a footpath. Two more parallel cables were added above the others to provide handgrips while crossing. These two cables, along with the bottom cables on each side, were lashed together to provide greater strength and stability.

These primitive, four-cable suspension bridges were built in Peru, China, and India, and are still being used today in some parts of the world. Impressive as they were, these early bridges lacked the permanence of the first structures built in ancient Egypt and Mesopotamia (present-day Iraq). In those countries, civilizations based on agriculture and trade arose around 3,000 B.C. Rather than creating wooden structures, the Egyptians and Mesopotamians built with stone and brick. The Egyptians are famous for the construction of the grand, stone structures known as the pyramids, while Mesopotamia was noted for its **canals** and irrigation systems.

These grand construction projects were possible because, for the first time, the governments of these kingdoms could tap the wealth of immense areas and command the labor of vast numbers of people. For the first time, governments maintained roads and bridges on a permanent basis. However, neither the Egyptians nor the Mesopotamians were noted for their bridge building. Both of these lands were arid, so there were few rivers to cross. The great rivers that dominated the life of these two civilizations – the Nile in Egypt and the Euphrates and Tigris in Mesopotamia – were simply too wide to span with bridges.

Rather than bridges, the Egyptians and Mesopotamians built vast canals and irrigation systems to provide water for agriculture and for city life. The Assyrians, who flourished in Mesopotamia around 1,000 B.C., built one of the grandest canal systems of the ancient world. The Jerwan aqueduct, which brought water from the mountains to the capital of Nineveh, was an important part of this canal system. An **aqueduct** is a type of bridge that carries water rather than people or freight. Discovered by archaeologists, the Jerwan aqueduct spanned a valley that lay across the canal. It was 920 feet long, 66 feet high, and contained about two million stone blocks. The passageway under the aqueduct carried a small river and roadway.

While its size alone is impressive, another notable feature of the Jerwan aqueduct is the use of the **corbelled** or false arch above the passageway. This is one of the earliest uses of the arch in brick or stone bridge construction. Surprisingly, the Greeks, one of the greatest builders of ancient times, did not adopt the arch in bridge building or construction in general. The Greeks, who flourished during the first millennium B.C., were noted for fine architecture – particularly beautiful stone temples such as the Parthenon. The Greeks employed a simple building-block style of construction, supporting their massive buildings with stone columns and lintels. **Columns** are vertical members that rest on the foundation of a building. **Lintels** are horizontal beams placed on top of the columns, spanning the distance between two or more columns. Their bridges employed the simple plank or beam design developed by prehistoric people.

The Romans, who reigned as the leading power of the Mediterranean world from about 300 B.C. to 476 A.D., made many notable advances in bridge building. The Romans were the first to develop engineering methods in construction. **Engineers** used mathematical calculations and surveys of the land to develop construction designs. They carefully planned the structures they designed, drew models of their design on paper, and supervised the construction work to ensure that it was done correctly. The Romans employed these engineers in their armies to direct the construction of roads, bridges, and fortifications. They also employed slave labor, which made many of their great construction feats possible. They were noted for their great roads and bridges, many of which are still in use today.

Roman engineers developed one of the most useful construction forms – the true arch. While the Assyrians and other cultures had used the arch, it had been a primitive type, called the false arch, which was not as effective as the true arch in supporting great weight. The Romans perfected the arch by adding the keystone. The arch itself was built of wedge-shaped stone or bricks known as voussoirs. The voussoirs were placed at the base of the structure in the shape of an arch. The last stone to be inserted in the arch was the **keystone**. It was inserted in the center, locking all of the other stones in place. With the keystone in place, the structure was built on top. As more weight was added, the stones in the arch pressed together. No mortar was used in building the arch because the weight of the structure held the bricks or stones in place. The true arch was a most effective means of supporting the great weight of stone or brick bridges. It was used in the construction of numerous buildings, bridges, aqueducts, and viaducts across the Roman Empire. This construction technique was one of the reasons that the Romans were able to conquer and unite most of Europe, northern Africa, and western Asia. Long after the Roman Empire fell, the true arch would remain the favored technique in bridge building.

After the fall of Rome in 476 A.D., Europe entered a period of grim and lawless times known as the Dark Ages, which lasted until approximately the 14th century. A marked decline in the arts and sciences, as well as in architecture and engineering, occurred. Roman bridge-building techniques were all but forgotten. The bridges of the Dark Ages were simple wooden plank bridges, hardly comparable to the grand, stone arch bridges of the Romans. However, certain monastic orders preserved Roman techniques, and helped start a new age of bridge building in the 12th century.

Near the middle of the 14^{th} century the Renaissance, a revival of learning, began spreading across Europe. Grand stone arch bridges began to appear again in Europe. However, these bridges were different from Roman ones in a remarkable way. In many cases, buildings were constructed on top of them along the **decks**. Traffic passed through stone archways or tunnels running through the buildings. Numerous buildings, including shops, apartment houses, and a chapel were built atop Old London Bridge, which was completed in 1210 A.D. The subject of the familiar nursery rhyme, Old London Bridge was over 936 feet long, with 19 pointed arches. This grand bridge, so much a part of English culture and history, lasted until 1831 when it was taken down.

Much of the Medieval Period was marked by warfare between kingdoms and internal rebellions. Bridges are extremely important in warfare because they provide transportation for troops and access to great cities. By holding a bridge, a small military force can fend off an attack by a much larger army. Gated and with fortress-like towers at both ends, Medieval bridges, like the castles of this period, could be defended by a small force. The roadways on the bridges narrowed at key points, making it possible to set up a second line of defense if the enemy penetrated the gates. The buildings on the bridges provided housing for troops and protection from projectiles during the battle. Another notable aspect of this bridge design that added to its military value was the huge stone piers. Many bridges featured piers that were two-thirds the width of the arches of the bridge. If any part of the bridge was destroyed, the remaining sections would remain standing and could be defended independently.

- Ask: What happened when people wanted to cross a river too wide to be spanned by a single log?
- Ask: What would have been used as anchors for primitive suspension bridges?
- Ask: What are some possible reasons that buildings were placed on Medieval bridges?
- Pass out vocabulary list. Go over terms with students as related to the lecture. Pass out crossword puzzle.

Activity 2 – Time Machine

- Time Machine Exercise: in the context of historical and environmental constraints, have students choose the type of bridge most suitable for a particular site. Assign each student, or group of students, a particular location and time period. For example, ask students what type of bridge would be suitable for a deep canyon in tropical, ancient India. Other possibilities could include a bridge over a narrow stream or wide river in the 18th century. Utilizing the knowledge learned from the previous discussion, students will formulate a bridge for a particular location and time. This can be done out loud in class or on paper as homework.

Activity 3 – Bridge Building

- Divide the class into appropriately sized groups to do an introductory bridge-building activity.
- Give each group two popsicle sticks, a ruler, and two wooden blocks.
- Ask them to place the blocks of wood 9cm apart.
- Ask them to build a bridge across the span. This will take little time as the students will realize all they have to do is place the popsicle sticks across the span and they are finished.
- Now refer to the Teacher Notes on plank and beam bridges. Use the parts of their bridges to introduce vocabulary terms.
- Now ask the students to move their two wooden blocks 15cm apart and ask them to build a bridge. After some deliberation they will say that it cannot be done.
- Give the students some Lego blocks (to build a pier) and ask if they can build a bridge now. Groups will brainstorm and eventually some will get the idea to build a pier.
- When they are finished, use the multi-span bridge constructed and introduce new vocabulary.
- Next ask the students to stack two more wooden blocks on each side and widen the span to 20 cm.
- Ask: What would they now need to build a bridge? They will probably indicate more legos.
- Tell them that the valley is too deep and there is no way to get down into it to build piers.
- Allow the students time to brainstorm possibilities. Elicit responses.
- Now refer to the Teacher Notes on suspension bridges to introduce the third type of bridge.
- Provide students with 4 strings, each 24 cm long, and tape; ask them to construct a bridge.
- Next Day: Ask the students what they had to do to stabilize their bridges from the previous day. Discuss the parts of their suspension bridges, anchors, etc. Mention that some rivers were too wide to construct bridges across. Lead into discussion of aqueducts.

- For K-3 students:

    - Students can do the first parts of the simple bridge building activity. Scale the material down considerably and introduce basic vocabulary terms and ask simple questions during the activity.
    - Students can also learn to physically show the different types of bridges with a partner. Arch bridge: one partner bends at the waist and places hands a couple of feet in front of feet on floor; the other student stretches arms straight out in front and places straightened arms on the “arched student.” Suspension bridge: partners can pretend to stagger back and forth as they walk across a suspension bridge on a windy day. Draw bridge: partners stretch arms straight out in front of them while touching fingers; when the teacher gives the signal, students slowly raise their arms to allow barges and other boats to pass beneath. Covered bridge: partners raise hands above their heads and bend slightly to touch hands together; other students can pass through while making clip-clopping sounds to imitate horses or try to imitate a babbling stream beneath the bridge.

Enrichment Activity/Alternative Activity

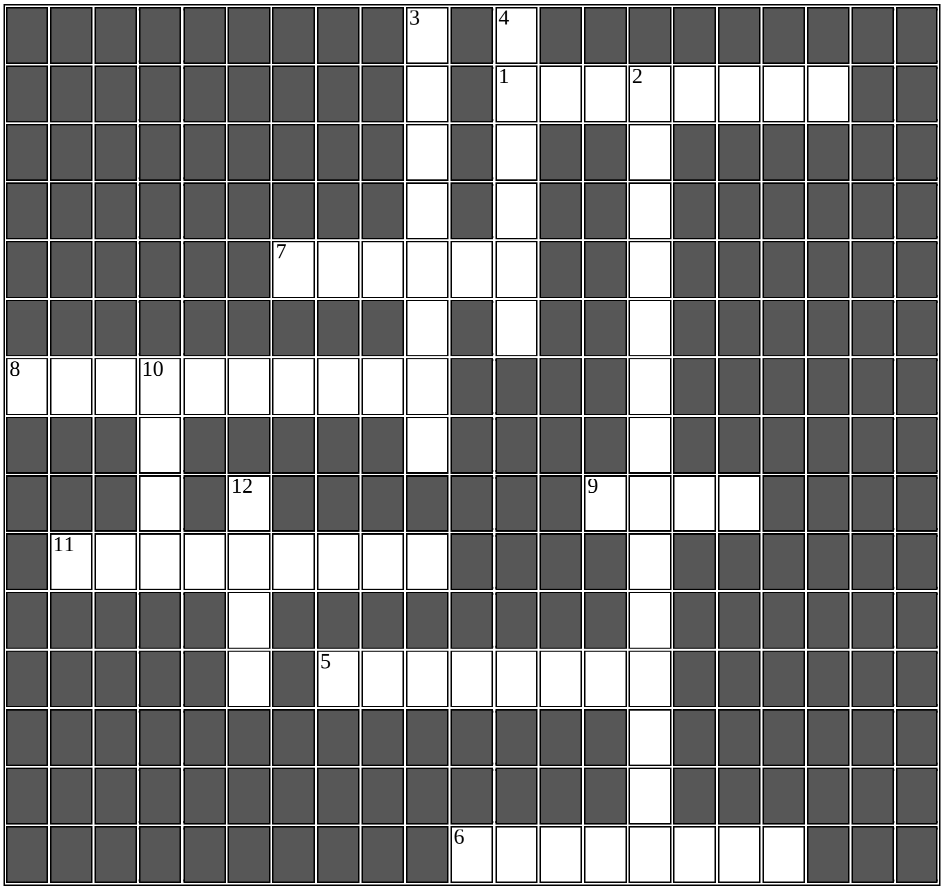
- For Grades 4-6:
    - The students can work in small groups or with partners to create bulletin boards (or posters) of bridge concepts. Pictures and sketches can be arranged on their displays with vocabulary words placed appropriately to demonstrate understanding of concepts assigned to the group. For example, an arch bridge with the term “keystone” placed at the top of an arch pointing to the correct wedge of stone would demonstrate an understanding of the term. Bulletin boards should be assigned with specific expectations given to the students before they begin. A scoring rubric could be used to evaluate/assess such a project.
    - Have students read any of the books listed in the sources section and report or discuss their findings with the class, in an oral or written report or presentation.

- For Grades 7-12:
    - Have students read any of the books listed in the bibliography and report or discuss their findings with the class, in an oral or written report or presentation.
    - Pass out copies of this lesson’s Teachers’ Notes. Have students write a two- to three-page essay on how bridge building technology has altered our economy, society, and culture.

Unit Two Vocabulary	
Abutment	A foundation, usually composed of stone, masonry, or timber, that supports the ends of the bridge at each bank. Bridges, regardless of the number of spans, can have only two abutments.
Aqueduct	A conduit or artificial channel for transporting water from a distance; a bridge-like structure that carries a water conduit or canal across a valley or over a river.
Beam or Plank Bridge	The simplest and most inexpensive type of bridge; consists of a horizontal beam that is supported at each end by abutments at the banks of the river. Beams carry their loads or forces in bending or flexure.
Canal	An artificial waterway for navigation, irrigation, etc.
Column	A rigid, upright support that rests vertically on the foundation of a building. It carries loads in compression and is used to support the roof or other parts of the building or bridge.
Corbel	An architectural bracket or member, especially of stone or brick, built into a wall and projecting from it to support a weight; a short horizontal timber supporting a beam.
Corbelled Arch	Also called a false arch, it looks like an arch, but works like a corbel.
Deck	The roadway of a bridge.
Engineer	A person trained and skilled in the design, construction, and use of buildings or machines.
Keystone	The wedge-shaped piece at the top of a true arch that holds the other pieces in place.
Lintel	The horizontal beam placed on top of the column, spanning between two or more columns or walls.
Pier	A support for the ends of adjacent spans.
Suspension Bridge	A type of bridge that suspends the roadway from large main cables, which extend from one end to the other; the cables rest on top of high towers and are secured at each end by anchorages. Primitive version could be a vine rope linking two sides of a chasm.

Name: ______________________________

The Covered Bridge as a Symbol



ACROSS

1. Foundation upon which weight-bearing beam rests
5. Type of bridge that carries water
6. Directs construction of roads and bridges
7. Horizontal beam placed on top of columns
8. Bridge made of vines
9. Arch type containing a keystone
11. Type of arch in aqueducts

DOWN

2. Reason bridges were important in warfare
3. Last stone inserted in center of an arch
4. Provide water for agriculture and city life
10. Supported ends of two planks
12. Primitive bridge made of single log

Answers to The Covered Bridge as a Symbol

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Answers can be found in vocabulary list and text.

<table>
<tr><th colspan="2">Unit Three: The Transportation Revolution and the Covered Bridge</th></tr>
<tr><th>Lesson One: The Transportation Revolution and the Covered Bridge</th><th>Grade Level: 5-12</th></tr>
<tr><td colspan="2">Learner Objectives</td></tr>
<tr><td colspan="2">Students will become familiar with the early transportation revolution in America and discover what role the covered bridge played in it.</td></tr>
<tr><td colspan="2">Common Core and National Education Standards</td></tr>
<tr><td colspan="2">

Reading Standards for Informational Text:
RI.K-12.7 – Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. (Activity 1)
Speaking and Listening Standards:
SL.K-12.1 – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others’ ideas and expressing their own clearly and persuasively. (Activity 2)
Social Studies:

Economics
NSS-EC.5-12.4 - Role of Incentives – Understand incentives can be monetary or non-monetary, understand the introduction of new products and methods is an important form of competition and is a source of technological progress and economic growth. (Activities 1 and 2)
Geography
NSS-G.5-12.1 - The World in Spatial Terms – Understand how to use mental maps to organize information about people, places, and environments in a spatial context, understand the processes, patterns, and functions of human settlement, understand the characteristics, distribution, and migration of populations, understand how physical systems affect human systems, understand how to apply geography to interpret the past. (Activities 1 and 2)
U.S. History
NSS-USH.5-12.4 - Era 4: Expansion and Reform (1801-1861) – Understand how the industrial revolution, increasing immigration, the rapid expansion of slavery, and the westward movement changed the lives of Americans and led toward regional tensions. (Activities 1 and 2)

</td></tr>
<tr><td colspan="2">Duration</td></tr>
<tr><td colspan="2">All grades – two 45-minute class periods</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">
✓ Transportation handout: The Pennsylvania Main Line Canal
✓ Transportation handout: James River and Kanawha Turnpike
✓ Canal, railroad, river, and road game questions
✓ Possible: four to five desk bells, dice
✓ Vocabulary list
</td></tr>
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Activity 1 – Notes and Discussion

- Pass out transportation and vocabulary handouts
- Introduce the topic with the following Teacher's Notes.

The Transportation Revolution and the Covered Bridge.

Teacher's Notes & Discussion

Today, most Americans view covered bridges as symbols of a much simpler era. However, when the first covered bridges were built, they represented an ingenious and imaginative development in carpentry. In fact, the development of the covered bridge was an important part of the tremendous expansion of America's road, canal, and railroad transportation systems during the first half of the 19th century. These new transportation systems linked the nation, provided for faster and cheaper movement of people and freight, and changed life so much that historians refer to them together as a transportation revolution.

In 18th-century America, roads as we know them did not exist. Furthermore, there were no railroads and canals. Our forefathers would not recognize airplanes, interstate highways, or Amtrak trains. We have come a long way since their time.

- Ask: How do you think people traveled during those days?

There were few options when traveling through the American colonies in the 17th and 18th centuries. The main highways in those days were **navigable** rivers and streams. Popular vehicles consisted of **canoes**, **flatboats**, and **keelboats**. Land travel was accomplished primarily by following **trails** carved through the woods by Native Americans. These trails were not wide enough to carry any kind of cargo, so the colonists mostly relied on river travel.

However, these trails deserve a deeper look because a lot of them became the roads we travel on today. As mentioned above, the trails were made by either animals, mostly buffalo, or Native Americans. This means that they were often the fastest routes by land. They avoided hills and stuck to the valleys, mostly following bodies of water. Before 1750, American colonists relied on these native trails for cross-country land travel. They also cleared their own footpaths between towns, but that was about the extent of their road building ventures at this time.

Two of the first important roads built by the American colonists, with the help of British soldiers, were the Braddock Road (1754) – the modern equivalent is US 40 – and Forbes' Road (1755) – the modern equivalent is US 30. Both were built in Pennsylvania. These roads were built for military purposes, but after the French and Indian War ended in 1763, colonists began to use these roads to travel west. The roads were still not very good to travel on. They were rough, muddy, and very rutted. In 1775, Daniel Boone cleared out the Wilderness Road, which allowed settlers to travel into what is today Kentucky. All three of these first roads were built following Native American trails.

- Ask: Why would Americans feel the need to develop a better inland transportation system? What would a better inland transportation system bring about?

After the Revolutionary War ended in 1781, the American people began to turn their attention to providing themselves with some kind of inland transportation system. In the 1790s private companies began to build **turnpikes**, also known as **toll roads.** If anyone wished to travel on these roads, they had to pay for it. Of course, many people did not mind the toll because the roads were usually better than the trails. These turnpikes were the first roads in America to have covered bridges. In 1806, the U.S. government commissioned the building of the **National Road** from Cumberland, MD, to Wheeling, VA. Crossing the Appalachian Mountains, this road was not opened until 1818. It was extended west as far as Illinois by 1850.

- Ask: What is a canal?

The American people were also interested in building **canals** at the end of the 18th century. It was still faster to travel by water than it was by land, and it was the only real way to transport very heavy or bulky freight. The problem was that there were not waterways everywhere people wanted to travel. Many canals were built during the period of "canal mania," from 1820 to 1950. Probably the most important canal built at this time was the Erie Canal. In 1817, ground was broken in Rome, NY to begin the work on this canal. By 1826, it was completed to Buffalo, NY along Lake Erie. Americans could now travel from New York City, along the Atlantic coast, to Buffalo in 8 days instead of several weeks. Canals began to sprout up all over America. They quickly became a favorite way to travel and ship goods.

The canals began to receive competition from early railroads in the 1840s. The most important railroad at this time was the Baltimore and Ohio (B&O) Railroad, which opened in 1842. When it first opened, this railroad ran from Baltimore to Cumberland, MD. In 1852, it reached Wheeling, VA. When many of the first railroads were built, they did not run on steam power. Passenger and freight cars were pulled by horses, just like carriages or wagons. The Charleston and Hamburg Railroad was the first line to use a steam-powered train in 1831. By 1837, there were about 200 railroads in use, being built, or being planned. Some of the early railroads had wooden, covered bridges, but most used iron, and later steel, for bridge building.

The United States experienced a rapid transportation revolution in the 50 years following the end of the American Revolution. People wanted to move west and settle new lands, merchants and farmers wanted to find faster and cheaper methods of shipping their goods, and people just wanted to travel easier and faster in general. These early methods of transportation, including covered bridges, allowed all of these things to happen.

Activity 2 – Transportation Trivia

- Go over the transportation handouts with students if time allows. If 1 day is all that is feasible, it is advised to give the transportation handouts to students 1 day prior to starting the lesson, instructing them to read the handouts at home.
- Divide the class into teams of three to five, depending on class size, for a game of Transportation Trivia. It is advisable to keep the number of teams to a maximum of five. The instructor can act as the moderator or the host or a student can be allowed to volunteer as the host.
- There are several ways to keep track of scoring. The easiest is to assign each group a number: 1, 2, 3 or 4. Group 1 will be asked the first question. If they answer correctly, they go again. If incorrect, Group 2 takes a turn. For each question a group answers correctly, that group gets 50 points. Keep a tally of scores on the chalkboard. Teachers can adjust the rules in accordance to their particular class.
- Another method is to have a moderator choose a question at random to ask all of the teams. Teams can use the desk bells or raise their hands to answer questions. Each correct answer earns that team 50 points. The team with the highest score wins and is rewarded with the title of transportation experts (teachers can modify this as well).

Unit Three Vocabulary	
Canal	An artificial waterway used for traveling, shipping, and irrigation
Canoe	A light boat with pointed ends, propelled by paddles.
Flatboat	A boat, usually for carrying freight, with a flat bottom.
Keelboat	A boat that is decked over and can be poled upriver against the current.
National Road	The government-financed road running from Maryland to Wheeling, WV, built beginning in 1808. In later years the road was extended to Ohio, then Indiana, and finally to Illinois.
Navigable	A body of water that is both deep enough and wide enough for ships to travel in.
Toll road	A road that would be used only after a person paid a fee, or toll
Trail	A track made by passage through wilderness; a beaten path
Turnpike	A toll road; a toll expressway; a main road

TRANSPORTATION HANDOUT: The Pennsylvania Main Line Canal

The Pennsylvania Main Line Canal was one of the most remarkable transportation systems ever built. Completed in 1834 during the nation's transportation revolution, it was constructed by the Commonwealth of Pennsylvania. This combination railroad-canal system ran 395 miles from Philadelphia to Pittsburgh. While most of the system was a canal that followed the routes of the Susquehanna, Juniata, Conemaugh, Kiskiminetas, and Allegheny rivers, a 37-mile section between Holidaysburg and Johnstown was a railroad. Known as the Allegheny Portage Railroad, this section was simply too mountainous to be crossed by canal.

The citizens of Pennsylvania became keenly interested in canal-building following the tremendous success of New York's Erie Canal, which was completed in 1817. Pittsburghers were particularly outspoken in their appeals to the Pennsylvania state legislature for some transportation system that would link them with the Atlantic seaboard. In response to this public pressure, the legislature passed a series of canal acts between 1824 and 1826 which authorized the "commencement of a canal, to be constructed at the expense of the state and to be styled 'The Pennsylvania Canal.'" Ground was broken for construction of the canal at Harrisburg, the state capital, on July 4, 1826.

The four sections of the Pennsylvania Main Line Canal were the Eastern, Juniata, and Western Divisions, and the Allegheny Portage Railroad. The Western Division started at Pittsburgh and ran upstream beside the Allegheny River to a junction with the Kiskiminetas River at Freeport. Workers used hand tools to dig a canal channel measuring 40 feet at the top and 28 feet at the bottom, 4 feet deep. The total length of the Western Division was 105 miles. To regulate water levels and allow for passage of canal boats, locks made of cut stone were built at intervals along the canal. A total of 68 locks were built along the Western Division.

An interesting feature of the Western Division was its 16 aqueducts (water bridges). They were built at points where the canal had to cross streams. The aqueduct carried the canal channel and tow path across the body of water. Many were made of stone or even iron, but some were made of wood. Several of the wooden aqueducts were covered. The aqueduct that crossed the

Allegheny River and brought the canal into Pittsburgh was one of the most interesting of this type of covered bridge.

The Allegheny River aqueduct was the longest in the entire Pennsylvania Main Line route. The contract for its construction was let in 1827, but it was not completed until 1835. This unique structure was 1140 feet long with seven close-set piers. It was 14 feet wide at the bottom, 16-1/2 feet wide at the top and 8-1/2 feet deep, with a foot bridge on one side and tow path on the other. It was, in effect, a giant trough that carried an estimated 2,000 tons of water.

The Allegheny River aqueduct was something of an early American marvel. One American traveler, Philip Nicklin, who visited in 1835, described it as an "enormous wooden trough with a roof, hanging from seven arches of timber, supported by six stone piers and two abutments." The great English writer Charles Dickens in his *American Notes* described the aqueduct as "another dreamy place…stranger than the bridge at Harrisburg….a vast low wooden chamber full of water."

The Allegheny aqueduct stood for only half a dozen years. This great marvel was hopelessly damaged by the force of pack ice on the Allegheny River, and had to be demolished. It was replaced by a new aqueduct, an iron suspension bridge, in 1845. This new bridge was built by the great engineer, John A. Roebling, who later became famous for designing the Brooklyn Bridge. The aqueduct is still in existence, though the canal is gone.

TRANSPORTATION HANDOUT: James River and Kanawha Turnpike

The James River and Kanawha Turnpike was one of the earliest improved roads in the United States. It was first proposed by George Washington in 1784 as a way to connect Richmond and the towns along the James River and Atlantic Coast to settlements in western Virginia and along the Ohio River.

Centuries before Washington was born, this route linking the eastward-flowing James River to the westward-flowing Kanawha River had been used for transportation, first by animals, including buffalo, then by American Indians. This trail across the Blue Ridge and Allegheny Mountains was used by the earliest European explorers and settlers as they made their way westward to trade with Indians or take up lands.

In 1785, just 1 year after Washington's proposal and 2 years after the close of the Revolutionary War, the Commonwealth of Virginia authorized the construction of "Koontz's New Road" for wagons from the headwaters of the James River to the navigable waters of the Kanawha River at the mouth of Kelly's Creek. Kelly's Creek (modern-day Cedar Grove) marked the terminal point of overland travel to Kentucky and points west. From there, travelers took flatboats down the Kanawha River to the Ohio River, then down the Ohio to Kentucky. By 1800, the road was completed all the way to the Ohio River, thereby eliminating the need for travelers to transfer onto flatboats at Kelly's Creek.

Koontz's New Road was merely a rough, dirt road. It was soon rutted and almost impassable. It was poorly laid-out and had few bridges. Travelers had to ford most streams, which made travel hazardous in times of high water. An improved road with a paved surface and well-constructed bridges was needed, especially after the boom in the development of the salt industry in the Kanawha Valley during the 1810s.

With salt makers in the Kanawha Valley clamoring for an improved road, the Virginia legislature authorized the construction of the James River and Kanawha Turnpike in 1820. By 1826 the James River Company had built an improved highway from the Valley of Virginia, through the salt fields in the Kanawha Valley, and on to Kentucky. The new highway was paved with stone, and included bridges over all major streams. To pay for its upkeep and repair, tolls were charged:

Wagon, team and driver	$.25
Four-wheeled riding carriage	$.20
Cart, or two-wheeled riding carriage	$.12 ½
Man and horse	$.06 ¼
Cattle, per head	$.00 ¼
Sheep or hogs, per score	$.03

Tolls were collected at several points along the state highway. At the toll houses, travelers passed through a gate known as a turnpike after paying their tolls. That is why even today, toll roads are known as turnpikes.

In January 1827, a stage line ran its first coach between Lewisburg and Charleston, and weekly service was soon established to the Ohio River. Within 10 years stagecoaches were operating on a regular schedule, carrying passengers and mail between Richmond and the Ohio River in 4-1/2 days.

This comparatively rapid travel was made possible by several well-built bridges. The principal engineer in charge of construction, Claudius Crozet, ensured that the bridges on the turnpike would be well planned and well built. Two large covered bridges were built in western Virginia: the first over the Greenbrier River at Caldwell and the second over the Gauley River at Gauley Bridge. Each bridge cost $18,000. Crozet praised the two-span (211 ft. each) bridge over the Greenbrier as being “one of the most splendid wooden bridges ever built … I know of only three instances where the span of this bridge has been exceeded; it is even 16 feet greater than that of the Schuylkill bridge.” Of the triple-span (160 ft. each) Gauley Bridge, Crozet proclaimed that: “This handsome monument of human skill and enterprise, at the confluence of two streams, and in the midst of remarkably wild scenery, looks exceedingly beautiful.”

No photos of the Gauley Covered Bridge exist, but it was probably a Burr truss. It had three spans, each span resting on stone piers. The stones were hand-dressed. The timber used for the bridge was hewn by hand using adzes and broadaxes. Both sides of the bridge were covered with weatherboard, and it was roofed with oak shingles. Four windows were placed on each side of the bridge to provide light for traffic. It was painted a gleaming white.

But the Gauley Covered Bridge, a “handsome monument of human skill and enterprise,” would not last. Even as it was being built, ferrymen up and down the Gauley River vigorously protested its construction. The bridge stood only until July 11, 1826, when it was destroyed by a fire caused by “persons interested in establishing a ferry at that point.”

TRANSPORTATION TRIVIA

CANAL QUESTIONS

1) Which important canal was started in 1817 and finished in 1826?
2) In what state was the Erie Canal located?
3) Name three ways in which canals were used.
4) In what year was the Pennsylvania Main Line Canal completed?
5) Between what two cities did the Pennsylvania Main Line Canal run?
6) What were the four sections of the Pennsylvania Main Line Canal?
7) What is an aqueduct bridge?
8) In what city was construction started on the Pennsylvania Main Line Canal?
9) How many aqueduct bridges were on the Pennsylvania Main Line?

RAILROAD QUESTIONS

1) What important railroad ran between Baltimore, MD and Wheeling, VA, and eventually to Missouri in 1856?
2) Which railroad was the first to use a steam powered train?
3) In what year did the C & H Railroad first use their steam powered train?

RIVER QUESTIONS

1) What type of boat was invented by the Native Americans and propelled by paddles or oars?
2) What type of boat has a flat bottom?
3) What type of boat can be poled upriver against the current?

ROAD QUESTIONS

1) Who and/or what carved the first trails through America?
2) What were the first two roads built in America by British soldiers?
3) What years were the Forbes Road and Braddock Road built?
4) Which pioneer blazed out the Wilderness Road?
5) What year was the Wilderness Road built?

6) What state did the Wilderness Road allow settlers to come into?
7) What type of road may be used only after the traveler has paid a fee?
8) What was one of the first roads built by the United States that ran from Maryland to, eventually, Illinois by 1850?
9) In what year did George Washington propose the James River and Kanawha Turnpike?
10) What was the name first given to the James River and Kanawha Turnpike?
11) A boom in what industry spurred the reconstruction of Koontz's New Road?
12) In what year was the James River and Kanawha Turnpike completed?
13) Concerning the James River and Kanawha Turnpike, what two towns did the first stage coach run between in 1827?
14) Who was the principal engineer in charge of construction of bridges on the James River and Kanawha Turnpike?
15) Over what rivers and in what towns in western Virginia were covered bridges located on the James River and Kanawha Turnpike?
16) What was the cost to build the two covered bridges in western Virginia?

CANAL ANSWERS

1) The Erie Canal
2) New York
3) Traveling, shipping goods, and irrigation.
4) 1834
5) Philadelphia and Pittsburgh, PA
6) The Eastern, Juniata, and Western Divisions and the Allegheny Portage Railroad
7) A water bridge that carried the canal channel and tow path across a body of water.
8) Harrisburg, PA
9) 16

RAILROAD ANSWERS

1) The B&O Railroad
2) The Charleston & Hamburg Railroad
3) 1831

RIVER ANSWERS

1) Canoe
2) Flatboat
3) Keelboat

ROAD ANSWERS

1) Native Americans and buffalo
2) Forbes Road and Braddock Road
3) Braddock (1754) and Forbes (1755)
4) Daniel Boone
5) 1775
6) Kentucky
7) Toll road or turnpike
8) The National Road or Cumberland Road
9) 1784

10) Koontz's New Road
11) The salt industry
12) 1826
13) Lewisburg and Charleston, VA
14) Claudius Crozet
15) Over the Greenbrier River at Caldwell, and over the Gauley River at Gauley Bridge
16) $18,000 each

<table>
<tr><th colspan="2">Unit Four: What Holds Up a Bridge?</th></tr>
<tr><td>Lesson One: Understanding Tension and Compression</td><td>Grade Level: All</td></tr>
<tr><td colspan="2">Learner Objectives</td></tr>
<tr><td colspan="2">Students will learn and demonstrate the concepts of tension and compression within the context of American covered bridges.</td></tr>
<tr><td colspan="2">Common Core and National Education Standards</td></tr>
<tr><td colspan="2">♦ Science:
o NS.K-12.2 – Physical Science – Students understand properties of objects and materials and position and motion of objects. (Activities 1 and 2)
♦ Mathematics:
o MD.1.4 – Represent and interpret data. (Activity 2)
o MD.2.10 – Represent and interpret data. (Activity 2)
o MD.3.3 – Represent and interpret data. (Activity 2)</td></tr>
<tr><td colspan="2">Duration</td></tr>
<tr><td colspan="2">All grades – one 45-minute class period</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">✓ Uncooked spaghetti sticks
✓ Sugar cubes
✓ Room with door and knob
✓ Jumbo marshmallows
✓ Rubber bands
✓ Flat erasers
✓ Wooden dowel rods
✓ Tag board or construction paper
✓ Large flip chart
✓ Pennies
✓ Tension and Compression in Everyday Life Worksheet</td></tr>
</table>

Activity 1 – Tension and Compression

- Ask: What holds bridges up? Why don't bridges fall? Have them write their answers on a piece of paper and turn it in for later use at the end of the lesson. At the end of this lesson, give the responses back to the students. Have the students correct their responses, sharing with the class their original response and how their newest responses have changed.
- Ask: What is a force? Have students give an example. Then define and discuss.

Tension and Compression

Teacher's Notes & Discussion

In order to understand how a bridge carries a load, it is necessary to understand the concepts of forces, tension, and compression. The most important forces acting on a bridge are the dead and live loads. (The dead load on a bridge is the weight of the bridge itself; the live load is the weight of cars and pedestrians on the bridge.) Most people do not realize that when they cross a bridge both tension and compression are occurring at the same time.

Compression forces may be described as those forces that push. Any force that pushes something from the outside is a compression force. A compression force may come from the sides of an object also. It does not always have to be a downward force, although this kind gives the best examples. Examples of compression forces may be found in everyday life. The bricks on the bottom of a wall are in compression because the weight of all the other bricks is on top of them. The seat of your chair is in compression when you sit on it.

- Ask: Can you think of any other examples of compression in everyday life?
- A material must be firm and rigid to withstand a compression force. Have students take a piece of uncooked spaghetti and squeeze it between their fingers. Push the ends of the spaghetti toward each other. Ask: What is happening? (The piece of spaghetti is bending.)
- This bending is called buckling. Buckling occurs when compression forces are applied to a long thin strip of material. If you push hard enough, the spaghetti will bend sideways and break.
- Next have students compress a sugar cube between their fingers. Ask: What happens with the sugar cube when you press on it? What did the spaghetti stick do that the sugar cube is not doing? (The sugar cube does not buckle.)
- Ask: What can we conclude from this experiment if we relate it to building bridges? (Parts of bridges dealing mainly with compression forces should be built from thick, broad shapes and firm, rigid materials.)

Tension forces may be described as those forces that pull. Any force that tries to pull the ends of something apart is a tension force.

- Have a volunteer personally demonstrate tension for the class. Have a student go to a door with a knob and grab hold of the doorknob and pull. Note to class: the student's arm is in tension when he/she pulls on the doorknob.
- Ask: Can you think of examples of tension in everyday life?
- Take another piece of uncooked spaghetti and pull on the ends of it, allowing the class to do the same with their own piece. Note that there is no buckling. This is because the spaghetti is under tension – not compression. Note: As long as they are strong enough, long thin strips of materials are perfect for resisting tension forces.
- Ask: What can we conclude with the knowledge gained in this experiment if we relate it to building bridges? (The parts of a bridge under tension would work best if they were rods, ropes, or cables. For example, these are found in suspension bridges.)

Now it is necessary to see how tension and compression work together. Compression and tension can occur on opposite sides of each other. In a bridge, the surface of the roadway is under compression from the force of the truck moving over the bridge. If the top half of the bridge is under compression, then the bottom half of the roadway is under tension. The tension side is being stretched apart while the compression side is being pushed together under the **pressure**. The best way to tell how tension and compression work together is to watch the process yourself.

- See the CD-ROM for a visual representation of tension and compression acting upon a bridge in the Grade 3-5, Bridge Building, Build a Bridge activity.
- Homework Activity: pass out worksheet titled Tension and Compression in Everyday Life.
- Modifications for grades K-3:
    - Since they need very visual examples, good objects to use in order to demonstrate tension and compression are marshmallows, taffy, tootsie rolls, etc. This way they can see the changes. They can also see how these things can hold shape pretty well, as long as they do not squash or pull apart.
    - Ask the group "Why don't bridges fall down? What holds up a bridge?" and record their responses on a large flip chart or the board. Ask what the word "load" means to them and record their answers the same way. Using their words, explain the correct meaning of the word load and how bridges must not only hold up themselves, but also carry added loads.

Activity 2 – Paper Bridge

- Have students work in pairs.
- Take tag board or construction paper and create a simple beam/plank bridge by making two lengthwise folds on each side of a 25 cm by 15 cm piece of this paper. The lengthwise folds should be about 2.5 cm on each edge, leaving a 10 cm width. Place the bridge on two books of equal thickness about 2.5 cm onto each edge of the books.
- Each pair is given a stack of pennies. Place the pennies one by one in the center of the bridge until it collapses. Record the number of pennies each bridge held before it collapsed. Kindergarten students can use stickers to represent pennies on a chart while older students should be able to write this.
- Redo this experiment three times with first and second grades. Kindergarten teachers can simply take the group averages or do it as a whole three times.
- Show students how to record this data in a data table. Older students (grades 3-6) can weigh the pennies and figure that total for their bridges.
- Now create another bridge like the first and place the two together, one facing up with the edges on the inside, and the other facing down with the edges on the outside. It should look like a hollow tube. Redo the penny experiment and record the findings.
- Now ask: Which bridge is stronger? Why do you think this? Create a simple bar graph to show the differences in the two bridges.

TENSION AND COMPRESSION IN EVERYDAY LIFE

1) These are examples of tension forces that you can observe in everyday life. Observe as many of these instances, or others that you may think of, as you can. Write a paragraph explaining what you learned from observing these examples.
    - Tire swing or regular swing with someone in it
    - Picking a flower
    - Leash, when walking the dog
    - Arm, when pulling a wagon
    - Tent
    - Rope bridge
    - Telephone wires
    - Suspension bridge
    - Inflated stadium dome
    - Steel cables supporting an elevator

2) These are examples of compression forces that you can observe in everyday life. Observe as many of these instances, or others that you may think of, as you can. Write a paragraph explaining what you learned from observing these examples.
    - Brick wall on a house
    - Top surface of a chair cushion
    - Push on the shoulders of your brother/sister, while they do the same to you
    - Pyramids
    - Telephone pole
    - Arch bridge
    - Elephant leg
    - Tree trunk
    - Laying your head on a pillow
    - Push on a wall with both hands

Unit Four: What Holds Up a Bridge?	
Lesson Two: How Do Specific Bridges Carry Weight?	**Grade Level: 5-12**
Learner Objectives	
Students will learn the concepts of tension and compression and be able to demonstrate their understanding of these forces within the context of American covered bridges. Students will also learn how different building materials react to tension and compression, allowing learners to understand which materials are more suitable when building bridges.	
National Education Standards	
♦ Science: o *NS.K-12.2 - Physical Science* – Students understand properties of objects and materials and position and motion of objects. (Activity 1) o *NS.K-12.5 - Science and Technology* – Students develop abilities of technological design, understanding about science and technology, abilities to distinguish between natural objects and objects made by humans. (Activity 1)	
Duration	
All grades – one 45-minute class period	
Materials	
✓ String ✓ Four equal-sized books ✓ Two same-sized chairs ✓ Wooden yardstick or balsa plank about the size of a yardstick	

Activity 1 – Bridge Handout and Experiments

- As a class, brainstorm a list of known types of bridges.

Suspension Bridges

The physics behind the very early suspension bridges is fairly simple. These bridges were built mainly out of hemp vines that had been intertwined to make **strands**. Ropes and **cables** are strong in tension. Tension is the most important force working on these bridges. The horizontally placed ropes used to build these bridges are called cables. These cables are attached to anchors at both ends of the bridge. When a person or a load crosses the bridge, it causes a tension force on the cables that pulls it inward or down. The tension pulling on the cables, in turn, pulls on the anchors, pulling them inward also. Therefore, in order for these bridges to work, the anchors have to be heavy enough and sturdy enough to support the weight of the load.

- Experiment for Suspension Bridges:
- Tie two loops of string around the tops of two hard cover books of similar size. Then tie a third piece of string to each loop so that it hangs loosely between the books. Press down on

the center of the string to represent a load. What happens? (The cables first tighten up; then, with a little more push, the cables pull the books in, and the book-towers collapse.)

- Next, stand two books about 6- to 10-inches apart. Put a stack of heavy books on one end of string to secure it to the table. Then pass the string over each book (letting some string hang loose between the two books). Place a second stack of books on the other end of the string. Press again on the center of the string. What happens? Have students take notice of how the anchorages (stacks of books) help to stabilize the bridge. To further explain this concept, also tie the string to heavier and sturdier anchors such as two chairs to show that heavier and sturdier anchors are the best for these types of bridges.

Plank Bridges

The physics behind plank, or beam, bridges is simple also. Early plank bridges simply started out as a piece of wood placed over a stream or ravine. These early plank bridge builders had to be careful because if the bridge was too long it would bend, sag, and then break under the loads. When a load is placed on a plank bridge, the planks work in both tension and compression: the top is in compression and the bottom in tension. This is called bending, and is how a beam carries loads to a support. The coupling of internal tension and compression forces creates a bending resistance that works against the external load. A long beam cannot support a large amount of bending. It will crack and fall down. Therefore a **pier** (or piers) is needed to shorten the **span**. The alternative to this is using larger planks, which is not always feasible.

- Experiment for Plank Bridges:
- Place a wooden yardstick or balsa plank between two chairs. Press down on the center of the plank to show that the plank is not strong enough to support the load by itself (notice the sag). Add another chair or column between the first two chairs to give support to the plank. Now press down on the unsupported sections of the bridge. What happens now? The wood does not sag as much as it did without the extra pier.

Arch Bridges

The stone arch bridges built by the Romans and later Medieval builders were based upon the principle of the true **arch**. The true arch is strongest under compression. The true arch was built out of **voussoirs**, wedge-shaped bricks or stones. Starting from the ends, these bricks were placed on a curved surface held up by supports called “centering” until they met in the middle of the span. The curvature enabled the sides of the bricks to bear evenly against each other. The center stone was called the **keystone**. The keystone held all the other bricks in place by pushing them together. This is precisely how the true arch works. The more weight that is put upon the arch, the harder the voussoirs press together. Of course, this pressure had to go somewhere. The pressure of the load within the arch is thrust along the arc of the arch's curve, which is at right angles to the sides of the block and ends up pushing against the piers, walls or abutments as the case may be. These supports must be strong enough to bear the thrust from the arch. The piers on these bridges were just as important as the arches. Most stone bridges that are left from these war-torn centuries have enormously thick piers. These piers or walls not only supported the weight of the arches and the rest of the span, but also prevented the base of the arch from moving outwards. This restraint is essential to an arch. Without it, the blocks will separate and the arch could collapse. Also, if a span were destroyed in battle or washed away by a flood, the adjacent arches would remain standing; so only one span would need to be replaced afterwards.

Truss Bridges

In **truss** bridges, such as the covered bridge, the triangle is the vital form. When you nail four pieces of wood together in a square or rectangle, with a nail at each corner, you can push the figure out of shape. A flimsy structure like this will not hold anything up. If any weight is put on it, especially moving weight, the structure might collapse. But when you nail three pieces of wood together, as a triangle, it cannot be distorted. The basic form does not change. (Demonstrate both concepts with a model that you built, or if time permits, have students build models themselves.)

There are two kinds of stress involved in truss construction: **tension** (when a member is being pulled or stretched), and compression (when a member is bearing weight). The most simple and basic of the trusses is a king-post truss. The basic composition of this truss is the triangle. (Use a model of a triangle, such as that above, but include an upright divider down the middle.)

An upright, called the king-post, divides the original triangle into two parts and greatly strengthens it. When the king-post is above the roadway, it is under tension because the lower **chord** is pulling down on it. At the same time, the downward pull of the lower chord and the king-post is under compression. They are being squeezed together between the upper and lower chords. If you turn the span over, putting the roadway on top of it, the situation is reversed. Now the king-post is under compression and the diagonals are under tension. When the truss is above the roadway the structure is called a **through truss**. When the truss is below the roadway it is called a **deck truss**. Covered bridges are always through trusses.

<table>
<tr><th colspan="2">Unit Four: What Holds Up a Bridge?</th></tr>
<tr><th>Lesson Three: How Strong are Certain Bridge Materials?</th><th>Grade Level: 5-12</th></tr>
<tr><td colspan="2">Learner Objectives</td></tr>
<tr><td colspan="2">Students will learn how different building materials react to tension and compression, allowing learners to understand which materials are more suitable when building bridges.</td></tr>
<tr><td colspan="2">National Education Standards</td></tr>
<tr><td colspan="2">♦ Science:
o NS.5-12.2 - Physical Science – Students understand motions and forces. (Activity 1)
o NS.5-12.5 - Science and Technology – Students develop abilities of technological design, and understanding about science and technology. (Activity 1)</td></tr>
<tr><td colspan="2">Duration</td></tr>
<tr><td colspan="2">All grades – one 45 minute class period</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">✓ Ruler
✓ Books
✓ Small toy car
✓ Steel ruler
✓ Two chairs
✓ Extra ruler for measuring
✓ Paper clips
✓ Vocabulary list
✓ Crossword puzzle</td></tr>
</table>

Bridge Building Materials

Teacher's Notes & Discussion

- Ask: What materials are commonly used in building bridges (wood, steel, rope, etc)? Next ask students why these materials are used today instead of flimsy materials such as paper, thin wood, etc.

In order to fully understand the physics of bridges, it is necessary to see how different building materials react to tension and compression. With this knowledge, it is possible to figure out which materials work best for each type of bridge. Stone is a material strong in compression, but weak in tension. It is not feasible to build a stone slab bridge, except for those with very short spans. The dead load of the stone slab would bring about a tension force on the bottom edge of the slab. More than likely the slab would break under its own weight. Therefore, it is not a good idea to build bridge beams out of stone because they are always in tension. The stone arch, made of voussoirs and a keystone, is a much better use of stone materials because the arch makes use of compression.

Wood is a material strong in both tension and compression. This material was used to build almost everything before the advent of iron and steel. The major issue with building bridges and other structures out of wood was that these structures were not permanent. They were susceptible to early deterioration due to decay and insect infestation and were easily destroyed by fires.

Bridge builders began using iron in the 19th century. They began using cast iron, which was cheaply produced and very strong. The problem was that cast iron was weak in tension. Engineers then discovered steel, another form of iron. Steel is a lot like wood – strong in both tension and compression, yet more permanent.

- Demonstration of Strength: Have students construct plank bridges using books as abutments with paper, wood, or metal. Have them roll a small toy car across and compare their results to determine why paper or other flimsy materials are not suitable for bridge-building.

It is very important that the right building materials are used to build structures. If they are not, bridges will collapse under heavy loads. But bridge materials must have another characteristic besides strength. They must also have elasticity. Elasticity is the property of a substance that enables it to change in length, volume, or shape in direct response to a force effecting such a change and to recover its original form upon the removal of the force.

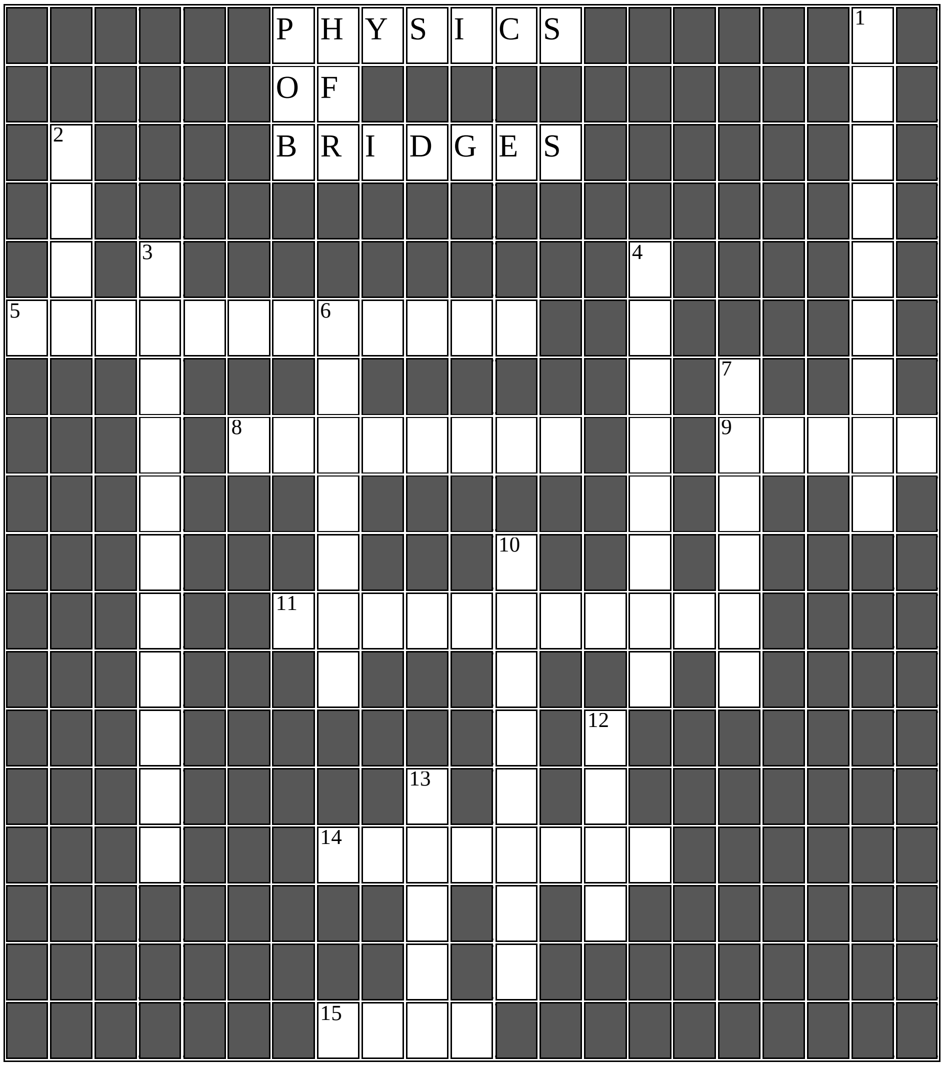
- Demonstration for elasticity: Secure a steel ruler between two chairs. Have another ruler ready to measure. Push down on the horizontal, supported ruler. Use the other ruler to measure how far the horizontal ruler goes down when you push it. Note: this act of bending or going down is called deflection. If you increase the pressure on the ruler, the deflection will be larger. If you stop pushing, the deflection disappears. Now push down hard enough so that a kink appears in the ruler. Notice that when you stopped pushing, the deflection did not disappear. This would be extremely dangerous if this happened to a bridge. Eventually, the bridge would collapse. Point out that this is why elasticity is a required characteristic of building materials for bridges.

Another material problem that engineers must deal with is fatigue. This is the gradual weakening of material when a force is applied and removed over and over again. All building materials are susceptible to fatigue.

- Demonstration for fatigue: Pass out paper clips to the class. Have them bend the curves out of the clips, making them as straight as possible. Next, have them bend the paper clips in the middle, back and forth several times. The wire will finally break after it becomes weak.
- Pass out vocabulary list and crossword puzzle.

Unit Four Vocabulary	
Arch	A curved structure of masonry, steel or timber, whose ends are fixed or held in place and in which the load is carried along it to the ground. Both horizontal and vertical support is essential at each end of the span. This is the difference between an arch and a curved beam.
Bottom Chord	The lower or bottom horizontal member of a truss.
Cables	A thick, strong rope made of fiber or steel.
Chord	Upper or lower members of a bridge truss; it may be a long single piece or a series of long pieces joined together at the panel points.
Deck Truss	A type of bridge truss in which the roadway is positioned on the top chord.
Keystone	The central wedge-shaped block at the top of an arch that holds the other pieces in place.
Pier	An intermediate foundation between the abutments of a bridge.
Pile	A long, relatively heavy timber, steel, or concrete member sunk or driven into the earth to provide a foundation when the ground is unreliable.
Pressure	The applying of constant force upon a surface.
Span	Portion of a bridge between two supports (abutments or piers).
Strands	A length of fibers, threads, filaments, wires, or hairs braided or twisted together to form a rope, cable, etc.
Tension	A force that stretches a material apart.
Through Truss	A type of bridge where the roadway is laid on the lower chords between the trusses.
Truss	A triangular system of timbers designed so that each member helps to support the others; together they support the weight of the structure over a span.
Voussoir	A wedge-shaped block found in a stone arch.

Name: ______________________________



ACROSS

5. Covered bridge whose roadway is laid on lower chords between trusses
8. Truss in which an upright divides the original triangle in two
9. Triangular system of timbers that support structure weight over a span
11. The act of pressing together, flattening or condensing
14. Slanted arrangement of rows or parts; under tension in a deck truss.
15. Heavy post or pillar used to support a bridge (intermediate foundation)

DOWN

1. Type of bridge where traffic uses deck on top of truss
2. Curved structure used to span open space such as a door
3. Bottom member of truss
4. Wedge-shaped piece of stone found in arch
6. Force that stretches a material apart.
7. Fiber, wire, etc. twisted to form cable, rope, etc.
10. Central wedge-shaped stone at the top of an arch
12. Portion of a bridge between two supports
13. Thick strong rope made of fiber or steel

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Answers to the Physics of Bridges

Answers can be found in vocabulary and text.

<table>
<tr><th colspan="2">Unit Five: American Covered Bridge Builders and Their Designs</th></tr>
<tr><th>Lesson One: American Covered Bridge Builders and Their Designs.</th><th>Grade Level: 5-12</th></tr>
<tr><td colspan="2">Learner Objectives</td></tr>
<tr><td colspan="2">Students will learn about some of the people who designed and patented the first covered bridges. They will also learn about the particular truss design of these early innovators and, by using the CD-ROM, understand how each truss worked under tension and compression.</td></tr>
<tr><td colspan="2">Common Core and National Education Standards</td></tr>
<tr><td colspan="2">♦ Reading Standards for Informational Text:
o RI.K-12.7 – Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. (Activity 1)
♦ Science:
o NS.5-12.2 - Physical Science – Students understand motions and forces. (Activity 2)
o NS.5-12.5 - Science and Technology – Students develop abilities of technological design, and understanding about science and technology. (Activities 1 and 2)
♦ Social Studies:
o Economics
▪ NSS-EC.5-12.4 - Role of Incentives – Understand that incentives can be monetary or non-monetary. (Activity 1)
▪ NSS-EC.5-12.5 - Profit and the Entrepreneur – Understand that entrepreneurs are individuals who take the risks of organizing productive resources to make goods and services. (Activity 1)
▪ NSS-EC.5-12.9 - Role of Competition – Understand the introduction of new products and production methods by entrepreneurs is an important form of competition and is a source of technological progress and economic growth. (Activity 1)</td></tr>
<tr><td colspan="2">Duration</td></tr>
<tr><td colspan="2">All grades – one 45-minute class period</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">✓ Covered Bridges CD-ROM
✓ Truss handout</td></tr>
</table>

Truss Builders

Teacher's Notes & Discussion

- Introduce the topic with the following Teacher Notes.

Wooden Trusses

Wooden truss bridges were first developed in Europe, but they did not see wide use on that continent because of the tradition of building in stone and because of the scarcity of wood. Americans were the first to adopt the wooden, truss bridge on a large scale. It is likely that American bridge builders based their covered bridges on European models. Images of wooden bridges are shown in a book written by Andrea Palladio, *The Four Books on Architecture*, printed in Venice in 1570. It is entirely possible that American's based their designs for wooden truss covered bridges on this book. We do know it was in the library of Thomas Jefferson. But, this was over 50 years before the first covered bridge was built in America. The Swiss also built large timber bridges, with spans over 300 feet. One good example, the Schaffhausen Bridge over the Rhine River, was completed in 1758.

Americans did not invent the wooden truss bridge, but they did develop the idea of placing a roof or cover over it. American bridge builders realized that the covering protected the main truss members from the weather. This would greatly lengthen the useful life of the bridge. Covered bridges were used for local roads, turnpikes, and on some canals. In the early days of railroads, timber truss bridges were also used on railway lines.

Covered bridges were built in over 30 different states during the 19th (1800s) and 20th (1900s) centuries. The designs of these covered bridges varied from state to state though because they were built by local craftsmen.

The American wooden truss bridge got its start in New England during the last 20 years of the 18th century. Wood truss bridges were built by Samuel Sewell at Boston in 1785; by William P. Riddle at Manchester, NH, in 1792; and by Enoch Hale at Bellow Falls, VT, in 1792. These bridges were not covered though. Some more important pioneers in the history of covered bridge construction were Timothy Palmer, Lewis Wernwag, Theodore Burr, Stephen Harriman Long, Ithiel Town, and William Howe. They made major contributions to the art of covered bridge building.

Timothy Palmer

Timothy Palmer of Newburyport, MA, was one of the earliest American wooden bridge builders. Palmer was never formally trained in carpentry or bridge building, but in 1797 he patented an original wooden bridge design. It was a combination arch and truss, multiple-span covered bridge. Early in his bridge-building career, Palmer built wooden bridges of this type over the

Merrimack, Kennebec, and Connecticut Rivers in New England, and across the Potomac River at Georgetown, MD.

His most famous bridge is the great three-span Permanent Bridge across the Schuylkill River at Philadelphia. It was completed in 1805. It was the final link in the Lancaster-Philadelphia Turnpike. Palmer first built this bridge uncovered. Judge Richard Peters, the president of the Schuylkill Permanent Bridge Company of Philadelphia, asked Palmer if a cover over the bridge would extend its useful lifetime. Palmer admitted that a cover could extend the life of the bridge by as much as 20 to 30 years. The Schuylkill Permanent Bridge Company then directed that weatherproof roofing and sidewalls be added to the Permanent Bridge. This bridge then became the first known example of an American bridge covered with a roof and siding to protect it from the elements. Palmer (1751-1821) built many bridges in New England and other parts of the nation.

Lewis Wernwag and the Colossus

Lewis Wernwag (1769-1843) is important for his work in Virginia and elsewhere. He represents the craft of bridge building at its finest. Wernwag was born in Germany in 1769, and came to Philadelphia at the age of 17. He was involved in a number of construction and business ventures in Philadelphia until 1810. During that year, he built his first timber bridge across Neshaminy Creek north of Philadelphia. After building several more bridges, Wernwag established his reputation as a bridge builder with the construction of the 340-foot, multiple-span covered bridge, the "Colossus of Fairmont," across the Schuylkill River.

For the next 12 years, Wernwag was involved in the building of numerous bridges and industrial buildings. In 1824 he bought Virginius Island at Harpers Ferry. There he established a manufacturing center. This move to Virginia brought him into contact with the B&O Railroad. He began to build bridges for the B&O. His most notable bridge was a Y-shaped covered bridge over the Potomac at Harpers Ferry. Wernwag also built the engine house at Harper's Ferry. This building became famous after John Brown's raid in 1859. Brown and his men occupied and held this building until U.S. forces under the command of Robert E. Lee captured them.

Theodore Burr and the Arch Truss Bridge

Theodore Burr was born in Torrington, CT in 1777. He designed and patented one of the earliest and most popular wooden truss bridge designs in 1804. Burr's design used both the truss and an arch. The arch, like the truss, is a form used to support weight in buildings and bridges. The arch was developed in the ancient world and used extensively by the Romans. Burr's design had an arch between each set of piers or abutments. It also had Kingpost trusses that were fastened to the arch. His design was known as the Burr truss.

Burr built dozens of covered bridges during his career. In 1818, he claimed to have built 45 bridges. His most famous bridge was the first bridge over the Hudson River in New York. It was a four-span bridge built in 1804 at Troy, NY. This bridge had spans ranging from 154 to 184 feet long.

Burr built bridges in many areas in the eastern United States. Unfortunately, he did not receive the fame that he deserved. This is due to the financial problems he had. In fact, at the time of his death in 1822, Burr did not even have enough money to pay for a decent burial. One of the most notable covered bridge designers in U.S. history was laid to rest in an unmarked grave in a potter's field somewhere in central Pennsylvania.

Despite Theodore Burr's lack of recognition during his lifetime, his design became one of the most popular and widely used for covered bridge construction in the United States during the early 19th century. Long after his death, covered bridges using the Burr truss were still being constructed over streams in the Midwest and other rapidly growing areas of the eastern and central United States.

Stephen Harriman Long

Col. Stephen Long (1784-1864) patented his famous wooden truss system in 1830. It marked the beginning of a new era in bridge building in the United States. Long pioneered a change in

American bridge building from an art by craftsmen into a professional activity guided by trained civil engineers.

Long was born in Hopkinton, NH. He graduated from Dartmouth College in 1809. He served as an assistant professor of mathematics at the U.S. Military Academy at West Point from 1814 to 1816. He was commissioned a second lieutenant in 1814. He served in the U.S. Army Corps of Engineers until his death in 1864. In addition to his bridge building, Long participated in a series of expeditions to the West.

In 1827, Long was assigned to the B&O Railroad to assist in choosing its route from Baltimore westward toward Wheeling. Long was not the only U.S. Army Engineer that provided aid to transportation companies. Others worked on canals, river improvements, mapping, and large-scale undertakings like the National Road from Cumberland, MD, to Wheeling, VA (later WV).

While working with the B&O in 1829, Long built his first bridge. This was the Jackson Bridge near Baltimore, which carried the Washington Turnpike over the B&O. Before this bridge, the B&O favored large stone structures following the traditional British and European practice.

One year after the completion of the Jackson Bridge in 1830, Long published *Description of the Jackson Bridge Together with Directions to Builders of Wooden or Frame Bridges.* This book showed Long's unique truss.

The Long truss was simpler than other designs. Long's design is important because it was the first to be based on engineering theory, rather than traditional practices. The key feature of the Long truss is the use of counter braces. Braces stiffen the truss against bending.

The Long truss was one of the first used in railroad bridges. At first, railroad companies were unsure that wood bridges would carry the heavy loads of railroad traffic. So, they favored stone arch bridges like those built by the ancient Romans. But these were expensive because of the large amount of labor required to build them. Timber bridges were much cheaper. And, since

Long had shown in his book how wood bridges could carry heavy loads, his truss design was used. During the 1830s, the Long truss was used widely in both road and railroad bridges.

Ithiel Town

Ithiel Town (1784-1844) was yet another important covered bridge designer and builder from New England. He was born in New Haven, CT. New England was the home of many covered bridge builders because the region had a well-developed ship building industry based upon heavy timber framing and an abundance of wood. And, of course, the region had many people with creative minds, what Americans call Yankee ingenuity.

Town's design was first patented in 1820. It was called the Town lattice. It was simply a lattice-work of thick wooden planks, pinned together with round pegs called treenails. Since it was easy to build, the Town lattice was used widely in New England and the Midwest. It brought wide-spread recognition to its creator. It was of simple construction and used relatively thin pieces of wood.

William Howe

William Howe (1803-1852) was a Massachusetts carpenter who developed a combination iron and wood covered bridge for railroad use. In 1838, the Boston and Albany Railroad hired Howe to build a timber railway bridge. Howe patented his new truss design in 1840. It represents the beginning of the transition from timber to iron for both railway and highway bridges. It was similar to Long's truss, but it replaced timber vertical members with iron rods threaded on each end.

The Howe truss was easy to erect. It could also be adjusted and its members replaced while in service. The Howe truss became the most popular bridge for railway use in America until the advent of the all-iron bridge in the 1840s and 1850s.

Activity 1 - Trusses

- CD-ROM – Use the CD-ROM to identify the trusses associated with each of these builders and others (Bridge Building – Trusses) and to examine how tension and compression work on each truss.

Name: ______________________________

Covered Bridge Truss Types

RABUHRRC	◯							◯	■	■	■
GNSIKTOP	◯							◯	■	■	■
EOPSUENQT								◯		■	■
RAMPEL					◯		■	■	■	■	■
ARWGWEN			◯					■	■	■	■
WEICNTATTOL						◯					
LOGN				◯	■	■	■	■	■	■	■
WEHO				◯	■	■	■	■	■	■	■
PDDARFODEL		◯	◯								■
HAUTP						■	■	■	■	■	■
WARNER	◯						■	■	■	■	■
TTRAP			◯			■	■	■	■	■	■
DCHILS			◯				■	■	■	■	■
SIHTM		◯				■	■	■	■	■	■

				■						■		■							?

These clues are scrambled versions of words that can be found in the Truss section of the CD-ROM.

Take the letters that appear in ◯ boxes and unscramble them to get the final message.

Answer the question in the box beneath it.

Answers To Covered Bridge Truss Types

RABUHRRC	B	U	R	R	A	R	C	H			
GNSIKTOP	K	I	N	G	P	O	S	T			
EOPSUENQT	Q	U	E	E	N	P	O	S	T		
RAMPEL	P	A	L	M	E	R					
ARWGWEN	W	E	R	N	W	A	G				
WEICNTATTOL	T	O	W	N	L	A	T	T	I	C	E
LOGN	L	O	N	G							
WEHO	H	O	W	E							
PDDARFODEL	P	A	D	D	L	E	F	O	R	D	
HAUTP	H	A	U	P	T						
WARNER	W	A	R	R	E	N					
TTRAP	P	R	A	T	T						
DCHILS	C	H	I	L	D	S					
SIHTM	S	M	I	T	H						

W	**H**	**A**	**T**		**M**	**A**	**K**	**E**	**S**		**A**		**B**	**R**	**I**	**D**	**G**	**E**	**?**

TRUSS

These clues are scrambled versions of words that can be found in the Truss section of the CD-ROM.

Take the letters that appear in boxes and unscramble them to get the final message.

Answer the question in the box beneath it.

Unit Six: Building a Covered Bridge	
Lesson One: Building a Covered Bridge	**Grade Level: All**
Learner Objectives	
Students will be able to identify the criteria used for locating a covered bridge building site. Students will be able to identify the tools and processes used to build a covered bridge.	
Common Core and National Education Standards	
♦ Writing Standards: o *W.4-5.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 2) o *W.K-5.3* – Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences. (Activity 2) ♦ Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects: o *WHST.6-12.3* – Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences. (Activity 2) o *WHST.6-12.7* – Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (Activity 2) o *WHST.6-12.8* – Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. (Activity 2) ♦ Speaking and Listening Standards: o *SL.K-12.1* – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (Activity 2) ♦ Science: o *NS.K-12.1 - Science as Inquiry* – Develop abilities to do scientific inquiry. (Activities 1 and 2) o *NS.K-12.2 - Physical Science* – Students understand motions and forces. (Activities 1 and 2) o *NS.K-12.5 - Science and Technology* – Students develop abilities of technological design, and understanding about science and technology. (Activities 1 and 2)	
Duration	
All grades – one to three 45-minute class period, depending on activities chosen	
Materials	
✓ Covered Bridges CD-ROM ✓ Bridge Parts word search	

Building a Covered Bridge

Teacher's Notes & Discussion

- Ask: Can anyone compare and contrast bridge building before the Industrial Revolution and bridge-building today?

Covered Bridges

Before the Industrial Revolution and the development of modern engineering, bridge building was a craft. There were no bulldozers or dynamite to move earth or relocate streams, no power machinery to shape bridge members, and no cranes to hoist members into place. Human ingenuity and skill were far more important than in today's construction. In those days before computers, the forces of tension and compression were poorly understood and pioneer engineers relied on a few simple mathematical calculations, rules of thumb, and trial and error to determine their designs. Also, in the actual construction, bridges were built by hand with a few crude tools, and a lot of hard work.

- Ask: What played an important role in determining if a covered bridge could be built at a certain location? Have students try to explain their answer.

The environment played an important role in determining where a covered bridge could be built. Since covered bridges are composed of wood, obviously a supply of lumber was required before construction could be undertaken. A variety of tree species were used: oak, poplar, chestnut, pine, spruce, and others. Since transportation was comparatively expensive in the first half of the 19th century, it was best to acquire lumber from nearby sources.

- Ask: Where do you think the majority of covered bridges were built during these times and why?

Because building covered bridges relied on local resources of the area, the majority of our covered bridges were built east of the Mississippi River, as well as along the West Coast where trees were plentiful. Furthermore, temperate western regions (California, Oregon, and Washington) naturally have more streams to cross than the relatively dry western states such as Wyoming or Nevada, therefore more bridges were required.

In addition to wood, a supply of building stone was required for construction of abutments and piers. Sandstone and limestone were typically used, but also granite and occasionally marble. However, the stone had to be quarried or dug from the earth using tools such as hammers or chisels. Few areas in the United States are without building stone but since stone is heavy, it was expensive to transport. This led bridge builders to locate building sites near a quarry, if possible.

- Ask: Who built these bridges? How did people afford to pay for the constructions of these bridges?

Even in the early 19th century, most covered bridges were built as public works. That is, town, county, or state governments paid the cost of their construction from funds collected from taxpayers. Only a small number of covered bridges were built and operated by private companies. These privately built bridges were then run as toll enterprises to pay for the cost of construction. When a town or government wanted a bridge built, it obtained bids from bridge builders who competed for the contract. No drawings were submitted. Instead, the builder often presented a scale model to represent the type of bridge he wished to build. The builder with the best design and reputation, and who presented the lowest bid, was usually awarded the contract.

- Ask: Can anyone tell how a site was chosen to locate a bridge?

The site for the bridge was selected by the town or other governmental unit, rather than the builder. There were no bulldozers, diesel shovels, or dynamite to move earth or relocate streams, so the natural terrain determined the location. They were usually located on an existing road where a simple ford had provided the only passage. Since most roads ran parallel to the streams they crossed, and it was desirable to cross a stream with the shortest bridge possible, many covered bridges were laid out at a right angle to the road and stream. This created a sharp turn in the road when entering or exiting the bridge. In the leisurely days of slow- moving, horse-drawn vehicles this condition was accepted. However, with the advent of automobiles these sharp turns became dangerous and led to the replacement of many covered bridges.

- **Possible Activity:** Students could be given a simple map illustrating a piece of land with a stream running through it with some portions having sources of trees and stone along with areas without such resources. The map could also have existing roads depicted. Then ask the students to choose where they feel would have been the best location for a covered bridge and why.

- **Ask:** Does anyone know the three specifications given to a builder when beginning construction?

With the contract signed and in hand, the bridge builder began his work. The builder was provided with a set of specifications for the bridge: its location, length, and width. His design was based on his model and, often, a set of rough drawings. The drawings had the sizes of the lumber, length of the span, and other vital information. The builder then selected the lumber, called on his masons, carpenter, laborers, and finishers. The number of people employed might range from 3 to 30, depending on the length of the bridge. Some large bridge companies had crews continually engaged in felling trees, shaping timbers, and forming trusses for the project. The trusses were then shipped to various bridge sites, where they were assembled. These companies were, in effect, engaging in the mass production of bridges. Most of the covered bridges were built individually for a specific site, however.

- Ask: What would be the first step in building a covered bridge once location, size, and materials were determined? Discuss why this would be the logical first step.

The first step in building a covered bridge is the construction of the abutments (the solid, stone foundation for the bridge on either side of the stream). Timber was also used for smaller bridges. Occasionally, it was possible to use a natural outcrop of rocks jutting from the bank, but this was rare. Most abutments were built of quarried stone, mainly limestone, sandstone, and granite, sometimes marble. Skilled masons took blocks of stone in various sizes and used a hammer and chisel to square them, or to make them symmetrical. The stones were then placed in layers or courses, and stacked to form a solid level foundation. They were usually laid “dry,” or without mortar between the joints. For bridges that were long enough to require two spans, it was necessary to build a stone pier or stone foundation in the middle of the stream. This was a more difficult task than building abutments, especially with swift-flowing or deep streams. A cofferdam, or temporary dam, was built around the location, and the stream bottom excavated to bedrock. Sometimes, in stream beds covered with massive layers of silt, bedrock could not be reached, so wooden poles known as piles were driven into the silt to provide a firm footing. A timber platform was erected on top of piles for a foundation for the masonry. Then masons began the work of building the pier, laying stone courses in the same manner as abutments, and finishing the top at the same level as the abutments.

- Ask: Does anyone know any of the types of tools used when building a bridge during that time? (The Tools section of the CD-ROM could be used during this portion as a whole class presentation or the students could explore on their own.)

As abutments were being built, wood workers were busy felling timber and shaping and joining them into trusses and other bridge members. Workers used only hand tools. Today, when we marvel at the nicely-squared timbers or perfect joints of a covered bridge, we are paying tribute to the great craftsmen of this period. A variety of special tools were used. To square the round timbers, both the broadaxe and adze were used.

The broadaxe was a short-handled cutting tool with a sharp blade. It was used to hew a round log into a square beam. The user notched the log at intervals, then hacked off chunks of wood between the notches until the log had a flat, if rough, side. He then repeated this process on the three remaining sides. Marks made by the broadaxe worker are clearly visible on the big timbers of many covered bridges.

The adze was used for smaller logs and to finish timbers. It is an arched blade hung at right angles on a stout handle. The adze worker straddled the log, bringing the sharp blade down between his legs, making wood chips fly as he shaped the timber. The adze worker was skilled at making notches so that one end of the beam could be fitted into another, and also for shaping straight timbers into slightly covered members for arches. Using an adze could be a hazardous job. In fact, the adze has been called the "devil's own tool for danger" because the sharp blade, swung so close to the feet and legs, could sometimes injure feet and tender shins. The old-time adze workers often bore the scars of their work.

The drawknife and plane were two other tools used for shaving wood down to the correct size. A drawknife is a sharp blade with handles in either end. It was used to shave short pieces of wood into pegs or treenails for fastening joints, or to finish shakes or siding. The drawknife was used with a shaving horse, a contraption that held the wood in place. The woodworker seated himself in the shaving horse, used his foot to clamp the wood to the working surface, then drew the knife toward himself to shave the piece. A plane is a very sharp blade fitted into a wood body. It was used to give hewn timbers more finish and smoothness. Unlike most of the other tools used in building a covered bridge, planes are still widely used today by woodworkers.

A hammer and chisel as well as a mechanical or hand auger and maul, were used to create one of the critical elements of the covered bridge: the mortise and tenon joint. While modern carpenters use nails or other fasteners to connect large wood members, traditional woodworks created a mortise and tenon joint for that purpose. A mortise, or broad slot, was fashioned with a flat tongue, or tenon, to fit snugly into the mortise. To strengthen the joint, a hole was bored through it with an auger and a peg, known as a treenail (pronounced "trunnel"), was driven into it. Although larger, the auger is similar in many respects to a modern drill. The pegs were driven home with a maul, a club-like hammer made of ironwood or oak.

The froe is another traditional woodworking tool. It was used to create shingles of wood to cover the roof of the bridge. The froe is a wide, shallow wedge or blade with a handle set at a right angle on the edge of the blade. Shingles were split from a block or bolt of oak, pine, or cedar with the froe and maul. Positioning the blade on top of a bolt of wood, the woodworker held the handle upright and struck the top of the blade with the maul. If the wood was clear of knots, off would split a shingle (called a shake), much like a thin piece of pie. Shakes were then finished with a drawknife.

- At this point refer to the CD-ROM for a visual representation of the construction of a covered bridge.
- Using the following notes, discuss the sequence used to build the bridge.

With the bridge members shaped and notched and the abutments laid, it was time to assemble the bridge. First, workers built scaffolding or false work over the stream in order to provide support for the lower chords and trusses when they were put into place. This job was made easier during winter because the frozen stream made a fine foundation for rough timbers. Then the trusses were assembled. There were two ways to accomplish this. Some bridge builders assembled the trusses on the ground, then moved the entire assembly to its final destination atop the abutments. Other builders put the trusses together piece by piece atop the abutments. In both cases, the trusses were first carefully fitted together on the ground near the bridge site. If a builder preferred to assemble it piece by piece, the trusses would not be fastened together at this time. Instead, workers marked each part in order to know how to fit them together later. Then they were reassembled on top of the scaffolding or falsework. If the trusses were assembled on the ground, they were hoisted into place as a unit in an operation requiring the entire work crew.

Rollers (usually simple, round logs) were placed under the truss and it was nudged out towards the stream an inch at a time. At the same time, a block and tackle (or a make-shift crane) was used to raise the top end of the truss into its correct position. Lines were attached to the top of the truss and horse- or man-power was used to hoist them into place. Slowly the whole side of the bridge moved out on rollers over the falsework in the stream, and slowly it rose into place.

With the trusses in place, they were joined together with bracing at the top and bottom. The roadway was then supported from the trusses. Joists, which support the floorboards, were laid over the lower chords of the trusses; then wide planks, or floorboards, were laid at a right angle to traffic. The floorboards took a terrific beating from traffic. To protect them, builders often laid running boards on top of the floorboards. Set parallel to the trusses and in the same manner as rails on railroads, running boards provided a surface for wagon wheels. They were usually replaced every few years. Sometimes the bridge was opened for traffic as soon as the roadway was laid, even before it was covered. In this case, workers added the roof and siding while the bridge was in use. The siding and roof were very important because they protected the structure, especially the trusses, from weathering. Nails were used in attaching the siding and shakes, often the only phase in construction where they were employed. Siding was cut at a local saw-mill, or made by splitting off long planks from bolts of wood in the same manner as shakes. These boards are called clapboards. They were sometimes attached to the trusses horizontally, but more often they would be nailed to the structure vertically with the seams between the boards protected by even thinner boards called battens. This type of siding is known as board and batten. The type of roof built was very similar to those used on barns. A triangular framework, or roof truss, was built and attached to the upper chords of the main trusses. Clapboards were nailed to this frame, then the shakes were nailed down in an overlapping pattern.

- Ask: Were the covered bridges painted?

Most never saw a drop of paint until modern times. Builders reasoned that well-seasoned siding, especially if it was a poplar or white pine (which weather well) did not need it. There were many exceptions though. Some bridges were painted barn red while others were white. In both cases, a lead-based paint consisting of white or red lead salts and linseed oil was used. Now illegal because of their toxicity, these lead paints acted as a fungicide and protected the wood from rot.

- Pass out Bridge Parts word search.

Activity 1 – Research Presentation

- Students could be assigned to groups of designer, masons, carpenters, laborers, and finishers. Each group would then research (using lecture notes, handouts, internet, library, etc.) their portion of the construction process and then present their job to the class- in the proper building sequence.

- For K-3 students:
  - This lesson could be simplified by focusing the discussion on the necessity of the bridge location to be near a source of trees and stone. They could also utilize the tool portion of the CD-ROM- Students could be placed in groups and assigned a tool to tell the class how it looked (using the CD-ROM as a visual aid) and how it was used. The building sequence could be discussed in simpler terms also: the stones were put in place first to hold the bridge up, then the trusses etc.

Tools for Building a Covered Bridge

BROAD-AXE: 10 inches wide at head by 24 inches long

The broad-axe is a cutting tool with a short handle and broad, sharp blade. This tool was used to hew or carve a round log into a square beam. The user notched or cut into the log at different areas. The user then hacked off chunks of wood between the notches until the log had a flat side. This was repeated until the log had four flat sides, a beam. Marks made by the broad axe can be seen on beams of covered bridges today.

PLANE: 22 inches long by 7 inches high

A plane is a sharp steel blade set inside a wood handle. The plane was used in two ways. One was to make hewn beams smoother. A second use was to take away parts of the wood to bring beams to an exact width. Planes are still used today. They are different than the planes of the past. Planes of the 19^{th} century or 1800s were often much larger. One bridge builder's plane measured nearly 3 feet long! The user stood over top the beam, and held it in place with his body. Then, he pushed the tool away from him. The sharp steel blade sliced off thin shavings of wood.

FROE: 13 inches by 13 inches

The froe is a wide, shallow wedge with a handle on the end. It was used to split shakes (shingles) or clapboards (siding boards) from large blocks of wood like pine, cedar, or oak. The user held the froe against the wood and hit the top of the blade with a maul. If the wood was straight-grained, a thin pie-shaped piece of wood split off. A piece that was short was a shake, a type of shingle. Shakes were used on roofs. If it was longer, it was a clapboard, used for siding. A draw knife and shaving horse were often used to finish the shakes and clapboards.

MORTISE CHISEL: 16 inches by 1-1/2 inches

The mortise chisel is a sharp steel blade set in a wood handle. It was used for carving or gouging out mortises for joints. After a beam was marked and cut with a buck saw, the mortise chisel was used to remove extra wood to make an indent or pocket in the beam. Another beam would be set into this pocket.

ADZE: 35 inches by 9 inches

The adze is a sharp curved blade attached to the end of a long, stout handle. It was used to hew or shape a round log into a square beam. It was most often used on smaller beams like braces, rafters, and floor sills. The broad axe was used on larger beams. The user straddled the log and brought the blade down onto the log using a chopping action. This removed excess wood and reshaped the log. The adze was often called the “Devil’s own tool for danger,” because the user could easily injure a leg or foot.

CROSS-CUT SAW: 60 inches by 12 inches at handle, with 4 inch-wide blade

The cross-cut saw had two types of teeth: sharp teeth for cutting wood; and raker teeth to pull sawdust from the cut. It was mostly used to fell trees and cut large beams. To fell (cut down) a tree, the sawyers first cut a notch in the tree with a double-headed axe in the direction they wanted the tree to fall then they began sawing on the opposite side, each man pulling the saw through the kerf (cut) in turns. As the tree began to fall, the saw was pulled out of the cut. This was done to prevent damage to the blade.

BEETLE: 36 inches by 8 inches

The beetle is a long-handled mallet with an oak head held to the handle with iron sheeting. It was an important tool for building a covered bridge. The beetle was used to drive the treenails or pegs that hold beams together into place. It was also used to nudge beams into place.

DOUBLE-BIT AXE: 35 inches by 9-1/2 inches

It is a long-handled cutting tool with a steel head that is sharpened on both sides. The double-bit axe was used for felling trees. Sometimes it was used for scoring (marking) logs for hewing with a broad axe. Usually, one side was kept razor sharp for cutting and the other side was allowed to dull somewhat. The dull side was used for the task of grubbing (removing saplings near the ground level), or trimming tree branches.

BUCK SAW: 26 inches high by 24 inches wide

The buck saw is a sharp steel blade mounted in a rigid wood frame. The frame kept tension on the blade for exact cutting. A wire or turnbuckle at the top was used to adjust the tension on the blade. It was used to cut small beams and for making mortise cuts. Modern buck saws have steel frames and look much different than the traditional ones.

CRANK AUGER: 31 inches long at base by 26 inches high by 15inches wide at handles

The auger was used to drill holes in bridge timbers. Such holes might be used for treenails (wooden pins used to hold joints together) or iron bolts. The cranking device reduced the effort needed to drill and meant that holes could be drilled more accurately. The angle of the drill could also be changed. By releasing bolts in the metal side rails, the entire top section could move forward or backward, changing the angle of the drilling.

HAND AUGER: 21 inches long by 16 inches at handle

This tool was also known as a breast auger or borer. The hand auger is simply a steel or iron drill-bit connected to a wooden handle. It was used to bore holes for the treenails or wooden pegs. Treenails connected two members together in a joint. The user placed the auger on the chosen spot and turned the handle. As the drill took hold in the wood, the user pushed down upon the tool using his chest (or “breast”), and continued turning the handle until the hole was completed.

DRAW KNIFE: 16 inches long by 7 inches

The draw knife is a razor-sharp blade with handles on each end. It was used for shaving and finishing shakes and clapboards and for making treenails. The draw knife was almost always used with a shaving horse. This is a device that held the wood steady while the wood was worked with the draw knife.

SHAVING HORSE: 34 inches tall by 52 inches long by 9 inches wide

A shaving horse was a 19^{th} century work bench and vice. The woodworker sat on the shaving horse. He used his foot to apply pressure to clam the work to the bench. The woodworker then pulled the knife toward him to shave the piece.

Name: ________________________________

Covered Bridge Word Search

R	L	U	E	A	L	E	L	L	A	R	A	P	S	D
E	A	F	R	A	B	N	A	P	S	J	X	L	C	P
D	T	C	U	D	E	U	Q	A	Y	C	N	A	A	R
R	N	D	T	K	L	P	T	W	M	T	B	T	F	E
I	O	E	C	M	J	G	O	M	M	L	K	T	F	G
G	Z	T	U	C	O	M	P	R	E	S	S	I	O	N
A	I	A	R	I	I	O	Y	S	T	N	A	C	L	I
N	R	L	T	V	S	P	T	P	R	A	T	E	D	R
C	O	U	S	B	T	A	T	B	I	E	L	Y	I	T
H	H	C	R	A	Y	F	O	R	C	E	T	O	N	S
O	E	I	V	E	R	T	I	C	A	L	R	F	G	T
R	C	T	D	E	R	E	V	E	L	I	T	N	A	C
A	A	R	L	A	C	I	R	T	E	M	M	Y	S	R
G	R	A	J	A	E	S	T	H	E	T	I	C	I	U
E	B	E	A	M	E	C	N	A	N	O	S	E	R	G

ABUTMENT
AESTHETIC
ANCHORAGE
AQUEDUCT
ARCH
ARTICULATED
ASYMMETRICAL
BEAM
BRACE
CALBE-STAYED
CANTILEVERED
COMPRESSION
FORCE
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SYMMETRICAL
VERTICAL

Find the hidden words in the word search. In this word search, words are placed horizontally, vertically and diagonally, both forwards and back-to-front.

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ABUTMENT
AESTHETIC
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SYMMETRICAL
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Unit Seven: Covered Bridges in the American Civil War	
Lesson One: Covered Bridges in the American Civil War.	**Grade Level: 5-12**
Learner Objectives	
Students will learn the role of covered bridges during the Civil War, including their role as transportation routes and in military actions of Union and Confederate forces.	
Common Core and National Education Standards	
♦ Social Studies: o *U.S. History* ▪ *NSS-USH.5-12.5 - Era 5: Civil War and Reconstruction (1850-1877)* – Students understand the course and character of the Civil War and its effects on the American people. (Activity 1) ♦ Technology: o *NT.K-12.3 - Technology Productivity Tools* – Students use technology tools to enhance learning, increase productivity, and promote creativity; students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works. (Activity 2) o *NT.K-12.5 - Technology Research Tools* – Students use technology to locate, evaluate, and collect information from a variety of sources; students use technology tools to process data and report results; students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks. (Activity 2) ♦ Speaking and Listening Standards: o *SL.6-12.1* – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (Activity 1) o *SL.6-12.3* – Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric. (Activities 1 and 3) ♦ Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects: o *WHST.6-12.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 2) o *WHST.6-12.3* – Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences. (Activity 3) o *WHST.6-12.4* – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Activity 2) o *WHST.6-12.7* – Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (Activity 2)	
Duration	
All grades – one 50-minute class period	
Materials	
✓ Teacher Notes	

Covered Bridges in the American Civil War

Teacher's Notes & Discussion

The Civil War (1861 to 1865) is the great divide in American history. Prior to the war, the nation was largely agricultural and rural. Slavery, the most ancient form of labor, flourished in the South. The vast majority of people, even in the North where some industry existed, lived on farms. Machines were scarce, and most work was accomplished by human or animal labor. In the agricultural economy of the early 19th century, wood was America's main building material. America's forests supplied the raw material for houses, barns, fences, tools and bridges.

The covered bridge, the most prevalent bridge type of this era, is the finest representative of this pre-industrial, Wooden Age. After the Civil War, everything changed as America went from an agricultural to an industrial nation. Some changes occurred rapidly: slavery was abolished in 1865. Other changes began after the war, but occurred gradually. The Industrial Revolution began in earnest after the war, but took 40 years to transform the nation. It turned America into a nation of factory workers and brought the automobile and hundreds of other machines into life. It also marked the beginning of the Age of Iron and Steel in building, especially bridges, and the eventual demise of the Wooden Age and the covered bridge.

Covered bridges were involved in many military actions during the Civil War and many bridges were destroyed. This unit examines the role of covered bridges in the Civil War. Why were covered bridges, and transportation routes, so important during the war? What role did covered bridges play in military actions of Union and Confederate forces?

- Ask: What was the prevalent type of bridge before and during the Civil War era? What changes began to take place after the Civil War? How did the Industrial Revolution change bridge building?

Bridges were a critical point of contention for Union and Confederate armies because they were the weakest link in the main transportation arteries: turnpikes, railroads, and canals. Transportation routes were important to Civil War armies for the movement of supplies and reinforcements, and for communications. In military terms, the transportation routes utilized by an army are known as lines of communication. Lines of communication link an army to its base-where supplies and reinforcements are available. Each side seeks to secure and maintain its lines of communication, and destroy those of the enemy. This is important both in advance and retreat. If an army is cut off from its base by the severing of its line of communication, it risks capture or defeat, and is forced to fall back. Since bridges were always the weakest link in the lines of communication of both Union and Confederate armies, they were important in many campaigns.

- Tell the class that they are now going to examine the role of covered bridges during the War.
- Why were covered bridges, and transportation routes, so important during the War?
- What role do you think covered bridges played in military actions of Union and Confederate forces?
- What are *Lines of Communication?* Discuss this using the information provided in the Teacher Notes.
- Introduce John Brown's Raid, referring to the Teacher Notes.

A covered bridge figured in one of the important events that caused the Civil War, John Brown's raid on Harpers Ferry, VA, in 1859. On October 16 and 17, John Brown and his band of 21 followers seized the federal government arsenal and rifleworks in an attempt to start a slave uprising. They also took possession of Lewis Wernwag's S-shaped covered bridge over the Potomac. This was a combination highway-railroad bridge used mainly by the B&O Railroad on its main line from Baltimore, MD to Wheeling, VA. In seizing the bridge, Brown hoped to prevent news of his activities from reaching authorities, and cut-off any forces that tried to stop him. When the B&O's Wheeling to Baltimore express train pulled in from the west for a midnight stop at the station near the bridge's mouth, Brown's men opened fire. The gunfire struck Heyward Shepherd, a B&O porter, in the back, and he later died. Ironically, Shepherd was an African-American freeman, the race that Brown was trying to free from bondage. No slaves rallied to Brown's cause, and federal troops under the command of Colonel Robert E. Lee captured Brown and his followers. He was later tried, convicted of treason, and executed. But his raid aroused the nation, and set it on a path to war. And, what happened to the Wernwag covered bridge? It was blown-up and destroyed by retreating Confederate forces on June 14, 1861, in order to sever the B&O mainline.

- Ask: Why would Brown seize the S-shaped bridge over the Potomac River?
- What do you think happened to the Wernwag covered bridge? (It was blown up by Confederate forces in 1861 to sever the B&O mainline)
- Introduce the *Philippi Races*, the first land battle of the Civil War.

Another Virginia covered bridge was pivotal in the first land battle in the Civil War, the so-called Philippi Races on June 3, 1861. The Philippi covered bridge was built across the Tygart Valley River as part of the Staunton Parkersburg Turnpike in 1852 by Lemuel Chenoweth. The story of how Chenoweth won a contract for building this and four other covered bridges on the turnpike has become a classic folk tale. Chenoweth designed a truss plan similar to the Burr arch, and built a wooden, scale model of his design in a knockdown framework that could be carried in his saddlebags. Then, he set out on the 200 mile trip to Richmond, where he attended the meeting of the Board of Public Works to compete with several other bridge builders for the contract. After several bidders gave long, drawn-out explanations of the merits of their bridge designs, Chenoweth, as the last bidder, got his chance. Rather than a long-winded explanation, Chenoweth assembled his scale model and placed it between two chairs. Then he deliberately stood on his model and walked its length. As he stepped down he spoke his only words: "Gentlemen, this is all I have to say." The authorities were so impressed with his model and his confidence in it, as well as his low bid, that they awarded him the five-bridge contract.

All of Chenoweth's covered bridges, including Philippi, were located in northwestern Virginia where slavery and the plantation system of eastern Virginia failed to take hold, and most of the people sided with the Union during the war. So when Confederate forces under Colonel George Porterfield set fire to several bridges on the B&O Railroad, many northwestern Virginians armed themselves and formed militia. They also invited General George McClellan, commander of Union forces in Ohio, to join them in defense. McClellan was personally known to Abraham Lincoln from the days when Lincoln practiced law in Illinois. McClellan's forces moved rapidly across the Ohio River in an attempt to capture Grafton, a critical B&O junction. Meanwhile, Porterfield's smaller force retired to Philippi, where it established an encampment. A small armed guard was posted at the covered bridge to protect the Confederate's line of communication. On the night of June 2, scores of Confederate soldiers camped inside the bridge, unaware that at dawn they would be attacked by a much larger Union force. At 4 a.m., the Union army surrounded the town and after the signal from a cannon shot, mounted their attack. The guards abandoned the bridge and the Confederates fled in panic. Only three causalities resulted from the skirmish, known as the Philippi Races, but it had a great impact on public opinion. General McClellan wrote such glowing reports of the skirmish that it was hailed throughout the

North as a major victory. McClellan's reputation was enhanced and he was soon named as Commander of the Army of the Potomac, the Union's main force.

What happened to the Philippi covered bridge? It was spared on this occasion. It also survived several invasions and guerilla raids during the war. With some strengthening and modifications, it stood up for well over a century, and was an important link on U.S. Rt. 250. In 1989, a disastrous accident nearly ended its life, however. A gasoline tanker leaked its contents onto the bridge and the gas was ignited by a back-firing automobile passing through the bridge. The resulting fire destroyed the bridge, so it seemed. But closer investigation revealed that the stout trusses, though charred, had not been destroyed. With painstaking care, the bridge was restored. Today, it still stands as a monument to Lemuel Chenoweth and the first land battle of the Civil War. It is also the only covered bridge in America situated on a major U.S. highway.

- Ask: What were the Philippi Races? Why do you think this minor skirmish has such an impact on public opinion?
- What do you think happened to this bridge? (It was spared but nearly destroyed later by a fire in 1989)
- Does anyone know how a covered bridge fits into the battle of Gettysburg?
- Cover the topic of Union forces taking control over the Susquehanna bridges referring to the Teacher Notes.

One of Pennsylvania's most famous covered bridges was destroyed during General Robert E. Lee's 1863 campaign that culminated in the battle of Gettysburg. As General Lee led the Army of Northern Virginia through southern Pennsylvania, Harrisburg and other towns along the Susquehanna River, and even Philadelphia, were threatened. To protect these towns, Union forces took control of the Susquehanna bridges. Colonel J.G. Frick and the 27th Pennsylvania Volunteers held the Columbia covered bridge, located between Wrightsville and Columbia. Built in 1832 by James Moore, the Columbia Bridge was over a mile long! At 5,620 feet it was the longest covered bridge in the world. When Confederate forces led by General John B. Gordon approached, Colonel Frick's troops beat a hasty treat across the long bridge and set it afire from end to end. Frick claimed that was "keeping the rebels out of Philadelphia," but it's likely that he overreacted since Gordon's force was small.

- What happened to this famous bridge of Pennsylvania? (Union forces set fire to it)
- Introduce Confederate General John Morgan's raids.

Some of the most daring raids of the Civil War were carried out by Confederate General John Hunt Morgan and his cavalry. Morgan's chief objective in his raids was the destruction of Northern lines of communication, so bridges were a primary target. Morgan's method for destroying covered bridges was to dump a load of hay in a span and set it afire. In the summer of 1863 Morgan led a band of 2,460 cavalry from Sparta, TN to lay waste to Union defenses in Kentucky and northward. Boldly crossing the Ohio River west of Louisville, KY, Morgan's band left a path of destruction in southern Ohio and Indiana. They torched covered bridges at Bergholz, Dunkinsville, Lore City, and Point Pleasant, OH. In addition, Union defenders at a covered bridge near Paint Creek, Ohio skittishly sparked a fire on that bridge when it was rumored that Morgan was nearby. Indiana lost covered bridges in Ripley and Dearborn counties to Morgan's raiders. Morgan and his force, depleted to just 335 men, were captured in Ohio on July 26, 1863 at West Point.

The Confederates used one of their covered bridges in a most unusual manner. The covered bridge located over the Pearl River near the Mississippi capital of Jackson was used as a prison for Union soldiers. Colonel Thomas C. Fletcher of the Missouri Wide Awake Zouave, who was wounded and captured by the Confederates during the Vicksburg campaign in December, 1862, wrote that he, along with 20 other officers, was "thrust into the old rickety ruin of a bridge which was yet standing above water, the remaining part having fallen down." Confederates had converted the old lattice bridge into an escape-proof lockup by boarding its ends. This bridge-prison, about 100 feet long by 18 feet wide, held 401 Union soldiers during much of the winter of 1862-1863.

One of the unsung heroes of the Civil War was General Herman Haupt, a railroad engineer and bridge designer who served as chief of construction and transportation for the United States Military Railroads. Haupt's main job was to keep railroads controlled by Union forces running. He rebuilt scores of railway bridges destroyed by Confederates, often erecting them in amazingly short periods of time. Many were simple trestles, a bridge supported from the streambed rather than by a truss, but he also built some wooden truss bridges. Haupt did not bother to cover his bridges because permanence was not a concern near the battlefront. Haupt was also responsible for destroying many Confederate covered bridges. In fact, he developed a special "torpedo" to accomplish the destruction quickly and efficiently. The torpedo was made by placing a charge of powder in a tin cylinder around an iron bold. To destroy a bridge, a hole was bored into one or more of the truss members, the torpedo inserted, and its fuse lit. The resulting explosion shattered the truss, and caused the bridge to collapse.

- If you were a general in the Confederate army what would be your chief objective or target? What was Morgan's method of destroying covered bridges?
- Can anyone think of other ways in which a covered bridge could be used during the war? Explain how the covered bridge located over the Pearl River was used as a prison for Union soldiers. What would conditions be like if you were a Union soldier being held in a rickety old bridge throughout winter?
- Does anyone know how else covered bridges were destroyed during this time? Note how General Herman Haupt destroyed Confederate covered bridges using his "torpedo."
- Review the material by asking: How would it benefit the Confederacy or the Union by destroying the bridges? What methods were used to destroy the bridges? How do you think this affected the armies and the people surrounding the bridges? What other purposes did covered bridges serve during the war?

Activity 1 – Research Presentation with Handouts

- **Enrichment:** Have students research a particular bridge or occurrence using the internet or other software and write a report based on the information. Have students develop handouts to accompany their reports and present the information to the class.

Activity 2 – Story Writing

- For lower grades: Have students listen to the lecture and then draw their own visual representations of what these scenes would look like. Then have them write their own stories as an observer or participant in the action.

Unit Eight: The Demise of the Covered Bridge	
Lesson One: The Demise of the Covered Bridge	**Grade Level: 5-12**
Learner Objectives	
Students will understand that due to the Industrial Revolution and mass construction of railroads, iron and steel began to replace wood in bridge-building, so few covered bridges were built in the second half of the nineteenth century. Furthermore, students will know that iron and steel were stronger, more durable, and more economically feasible.	
Common Core Standards	
♦ Science: o *NS.K-12.2 - Physical Science* – Students understand properties of objects and materials and position and motion of objects. (Activity 1) o *NS.K-12.5 - Science and Technology* – Students develop abilities of technological design, understanding about science and technology, abilities to distinguish between natural objects and objects made by humans. (Activity 1) ♦ Social Studies: o *U.S. History* ▪ *NSS-USH.5-12.6 - Era 6: The Development of the Industrial United States (1870-1900)* – Students understand how the rise of corporations, heavy industry and mechanized farming transformed the American people. (Activity 1)	
Duration	
All grades – one 50 minute class period	
Materials	
✓ Teacher Notes ✓ Plywood plank ✓ Piece of steel or iron	

The Demise of the Covered Bridge

Teacher's Notes & Discussion

The 19th century was the heyday of the covered bridge, but most of the important ones were built before the Civil War (1861-1865). From 1805, when Timothy Palmer's "Permanent Bridge" across the Schuylkill River near Philadelphia was completed, until the Civil War began, the wood truss covered bridge was the most prevalent type of bridge in America. It was the "cutting-edge" bridge technology during the first half of the 19th century used on major road, canal, and railroad systems because it was cheap to build and was fashioned from wood, a readily available material. But, after the Civil War, as the Industrial Revolution got underway and railroads replaced turnpikes as the nation's major transportation links, iron and steel began to replace wood in bridge building, and those materials were used on most major bridges in the second half of the 19th century.

- Ask: Why do you think bridge builders turned from wood to iron and steel in constructing bridges? Was this transition a result of technological change? Were wooden covered bridges built after the Industrial Revolution? If so, why?

To understand why bridge builders eventually turned to iron and steel, we need to see how wood and the various kinds of iron compare in terms of their strength in tension and compression. The properties of wood vary by species, but in general, wood is weaker in tension and stronger in compression. The weakness of wood in tension is demonstrated by the fact that tension members tend to pull apart at the joints under heavy loads. Covered bridge builders developed new designs, such as the Burr arch, and used heavier timbers to strengthen them, but the inherent weakness of the material meant that there were strict limits to how much weight a wooden truss bridge could carry safely.

Iron is an element found in the earth in the form of iron ore. After mining, iron ore can be processed into three types of products: cast iron, wrought iron, and steel. Cast iron is obtained by heating iron ore in a furnace with limestone and carbon fuel either charcoal or coke (a refined form of coal). The iron combines with small amounts of carbon from the fuel, and turns into fiery liquid. When the furnace is tapped, the liquid iron can be cast into various shapes, hence the name “cast” iron. Cast iron is hard, but very brittle. For building purposes, it is good in compression, but weak in tension. Wrought iron can be made directly from iron ore, but in the 19th century, most wrought iron was made from cast iron. The cast iron was refined in a furnace so that nearly all the carbon was burned off, leaving a spongy mass that could be tooled or hammered into a variety of shapes. Wrought iron is tough and durable, but relatively soft. It is strong in tension, and only slightly weaker than cast iron in compression. Wrought iron is better for building bridges and other structures. But, unlike cast iron, wrought iron could only be made in small batches in the 19th century, so it was expensive.

- Then introduce steel, which replaced the wood truss bridge. Ask: Why would steel be a better alternative for bridge building after the 1880s?

Steel is much better than cast iron or wrought iron for building. Like wrought iron, steel was commonly made from cast iron in the 19th century. Cast iron was refined in a furnace, but not all of the carbon was removed, and alloys, such as manganese or nickel, were added. The result was a product that can be cast like cast iron or shaped like wrought iron. Steel combines the hardness of cast iron with the toughness of wrought iron. It is good in both tension and compression. For nearly every purpose (structural members for bridges and buildings, railroad track, and barbed wire) steel is immensely superior to other kinds of iron. Steel could only be made in small batches until around the time of the Civil War, so it was expensive and rarely used in construction.

- Ask: Can anyone give an example of a modern-day steel bridge? After students give examples, such as the Golden Gate Bridge, show pictures of famous steel bridges. Ask: Do you think a wooden bridge would have been able to do the job that these bridges do?

These three forms of iron were manufactured in pre-industrial America, but in comparatively small quantities. They were used mainly in the manufacture of tools and weapons. Since wood was plentiful, it was the common building material. Wooden truss bridges were perfectly fine for turnpikes, where the maximum load was a fully loaded wagon or a company of soldiers. But, a technological innovation in transportation changed all that. In the 1830s, the first railroad appeared in America. Designed to carry heavy loads, railroads presented great problems for bridge builders. They immediately recognized the drawbacks of wooden bridges. Not only were they susceptible to fire and decay, but, more importantly, they lacked the strength required to carry the great weight of railroad traffic.

Some railroad companies turned to stone to construct stronger bridges. But as permanent and as strong as stone bridges were, they were also very expensive to build. They required tremendous amounts of labor, and in America labor was expensive. So, other railroad companies turned to iron, at first the combination wood and iron truss bridge, then the all-iron truss bridge.

William Howe, a Massachusetts millwright, was the pioneer in designing the combination wood and iron truss bridge. He invented a bridge truss in 1840 that incorporated wrought iron in the design. Howe recognized that wood was weak in tension and that upright wooden posts used in the Long and Kingpost trusses pulled apart at the joints when under heavy loads. So, he replaced the verticals with wrought iron tension rods that could be adjusted with nuts and turnbuckles. The remaining components of the bridge were wood, and it was covered. The Howe truss and other types of combination wood and wrought iron covered bridges were widely used in railroad bridge construction from the 1840s until around 1880.

The all-iron truss bridge was the next attempt by railroad companies to build a stronger bridge. The first successful all-iron bridge in the country, the 1839 Dunlop Creek Bridge at Brownsville, PA, on the National Road, carried its load on cast-iron arches. This design did not catch-on, however. Instead, American bridge builders developed iron-truss designs based on earlier wood truss covered bridges. Richard Osborne erected America's first all-iron truss bridge in 1845 on the Reading Railroad at Manayunk, PA using a wrought-iron Howe truss. But, the greatest iron-truss bridge builder was not Osborne, but Wendell Bollman, a self-taught engineer from Baltimore, MD. Bollman was "master of road" for the B&O Railroad, which built the nation's first trans-Appalachian railroad from Baltimore, MD to Wheeling, VA, during the period from 1824 to 1852. Many of the railroad's first bridges were built of wood, and by the 1840s needed replacing. Bollman worked out a design that used a combination of cast iron and wrought iron that took advantage of the properties of each metal. Cast iron was used in compression members and wrought iron in tension members. The Bollman design was patented in 1852. Although complicated in appearance, it was easy to erect. The B&O built over 100 Bollman trusses during the years from 1852 to 1875.

But it was the steel rather than iron that eventually replaced the wood truss covered bridge. The Age of Steel was actually ushered in before the Civil War with an important technological innovation. In the 1850s, Henry Bessemer, an Englishman, and William Kelly of Kentucky, developed a process for the mass production of steel. Independently of each other, they discovered that a stream of air directed into a mass of molten cast iron caused the carbon and other impurities to combine with oxygen and burn off. With the addition of alloys, the brew 1860s, the Bessemer process, as it was called, was introduced commercially. By the 1870s, hundreds of thousands of tons of steel were being produced in the United States each year.

With steel available in such large quantities, American bridge builders began the transition from combination wood and iron bridges and all-iron spans to steel bridges. James Eads' steel arch bridge across the Mississippi River at St. Louis was completed in 1874, but extensive use of steel began in the 1880s. Better steel was available because of another technological innovation in steel making, the development of the open-hearth furnace. Open-hearth steel mills, like those that began to line the banks of the Monongahela River in Pittsburgh, produced low-cost high-quality steel perfectly adapted for bridge building.

By the 1880s, railroads had surpassed highways and canals as America's most important form of transportation. Turnpikes, once so important to travel, languished and many covered bridges went into a state of disrepair as traffic was diverted from highways to railroads. However, wood truss covered bridges continued to be built after 1880, and well into the 20th century. In fact, many that remain today date to the 1880 to 1900 period. But, these covered bridges were constructed on secondary roads in the most rural parts of the country, not on major thoroughfares like the first generation of covered bridges. They were fine for the occasional wagons, carriages, pedestrians, or a few head of cattle. But even these remote covered bridges became outmoded by the 1920s with the arrival of the Automobile Age. Americans once again took to the highways in large number, but by this time, bridges were being built of steel and concrete rather than wood.

- **Enrichment:** To demonstrate the strength of wood versus steel, bring in a thin piece of wood, such as a narrow plank of plywood. Place the wood across two objects, such as chairs, and set something heavy on it. Allow students to watch the board sag. Then place a piece of steel, if available, across the chairs and do the same. Have students compare the difference. Point out that not only is steel good for planks, but also used in suspension bridges as cables.

Unit Nine: The Legacy of the Covered Bridge

Lesson One: The Legacy of the Covered Bridge | **Grade Level: 5-12**

Learner Objectives

Students will learn that most covered bridges that were built are now gone. Students will learn the reason for the disappearance of the covered bridge from the American landscape. Students will also examine which covered bridges are left today.

Common Core and National Education Standards

- Technology:
  - *NT.K-12.3 - Technology Productivity Tools* – Students use technology tools to enhance learning, increase productivity, and promote creativity; students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works. (Activity 2)
  - *NT.K-12.5 - Technology Research Tools* – Students use technology to locate, evaluate, and collect information from a variety of sources; students use technology tools to process data and report results; students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks. (Activity 2)
- Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects:
  - *WHST.6-12.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 2)
  - *WHST.6-12.4* – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Activity 2)
  - *WHST.6-12.7* – Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (Activity 2)
- Social Studies:
  - *Geography*
    - *NSS-G.5-12.1 - The World in Spatial Terms* – Understand how to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective. Understand how to use mental maps to organize information about people, places, and environments in a spatial context. Understand how to analyze the spatial organization of people, places, and environments on Earth's surface. (Activities 1 and 2)
- Science:
  - *NS.5-12.5 - Science and Technology* – Students develop abilities of technological design, and understanding about science and technology. (Activity 1)

Duration

All grades – two 50-minute class periods

Materials

- ✓ Teacher Notes
- ✓ Covered Bridges CD-ROM
- ✓ Internet research capabilities
- ✓ PowerPoint presentation capabilities

The Legacy of the Covered Bridge

Teacher's Notes & Discussion

- Ask: What happened to the thousands of covered bridges that were built? Do you know any notable covered bridges that remain? Where are they?

We know that after the Industrial Revolution gained momentum after the Civil War, steel replaced wood as the principal building material for bridges. Few covered bridges were built after the 1880s. The few that were built after this decade were located on rural routes, not the main thoroughfares of railroad and highway traffic.

Thousands of covered bridges were built before the 1880's, and some afterward. Since historical records in some parts of the country are incomplete, we will probably never know the exact number. We do know that most have disappeared, and today there are only about 885 covered bridges left standing. This leads to several questions, which we will explore in this unit: What happened to the thousands of covered bridges that were built? What notable covered bridges remain? Where are they?

- Ask: What specifically could cause the disappearance of covered bridges? (Floods, fires, rot, poor maintenance, etc.)

What happened to cause the disappearance of most of America's covered bridges? Flooding, fire, deterioration due to rot, and lack of maintenance have been major causes of the demise of the covered bridge. Floods have destroyed many covered bridges as well as many other types of bridges. Covered bridges are more susceptible than modern bridges to being swept away by floods for two reasons. First, covered bridges are often poorly anchored to the abutments and piers. Often the weight of the bridge itself is all that keeps it in position. Onrushing water can easily dislodge them. Second, covered bridges are enclosed, like a rectangular box, so water cannot pass over their decks. Instead, the force of the flood hits the bridge broadside, forcing it off its piers and abutments and floating it away.

Fire has destroyed nearly as many covered bridges as floods. Covered bridges were covered to preserve the trusses and floor systems, but the light weight roofing and siding are highly flammable. As a bridge ages, its roof and siding season or dry. It requires only a small blaze to ignite the siding or roof, and the fire quickly spreads to the roof and trusses. Even if the fire destroys only the siding and roof, the bridge may soon be lost to rot if it is not promptly re-covered. As we have shown, some covered bridges were burned for military reasons during the Civil War. Others have been lost to arsonists. But, probably just as many have been burned by accident. For example, the Philippi Covered Bridge in Barbour County, WV, was burned accidentally in 1989 after a tanker truck spilled gallons of gasoline on it. A car passing through the bridge back fired, igniting the gasoline. Fortunately, no one was injured, but most of the bridge was lost. It was later restored, however, and some of the original members were saved.

Many more covered bridges have been lost because of a combination of three factors: deterioration due to rot, lack of maintenance, and use by overweight vehicles. This process usually starts after truck and other vehicular traffic far heavier than what the bridge was designed for begin to use the bridge. The extra weight causes wood members to crack and the joints, the Achilles' heel of covered bridges, weaken and separate. Moisture enters the loosened joint or crack, allowing fungus, the cause of rot, to grow. As a result, the truss members rot and the bridge grows weaker. If the bridge is not repaired or strengthened, and if the overweight traffic is not stopped, it will eventually collapse. In most cases, traffic engineers detect the deterioration before outright collapse. Usually, they demolish the covered bridge and replace it with a modern concrete and steel bridge.

- Continue the lecture and discussion. Then ask the students: Have any bridges been restored? How did engineers manage to restore some bridges that were in bad condition? Why haven't engineers been able to restore the bridges as historically appropriate?

In some cases, sympathetic engineers have repaired damaged covered bridges. Most of these repairs, especially those undertaken before the onset of the historic preservation movement in the 1960s and 1970s, have been done inappropriately. That is, elements have been added to bridges that were not part of their original designs. For example, cement is used to fill the gap in a loosened joint, or a truss is given extra support with steel straps. A more common way to strengthen a bridge is to add additional support to the floor system. This is done by placing steel beams under the floor or by building a new pier under the bridge in the middle of the span. These types of repairs are incorrect from the perspective of true historic preservation, but they have saved many covered bridges. Some of these bridges have been properly restored later.

What's left today? The most recent (1997) count of covered bridges in the United States put their number at 843. Unfortunately, we have lost several since 1997. For example, in September 2002, the Cedar Covered Bridge at Winterset, IA, a Town lattice truss with a flat top built in 1883, was destroyed by fire. The loss of the covered bridge was especially disturbing because it was one of the famous "Bridges of Madison County" mentioned in the book and movie of the same name.

- Ask: How many bridges are left today? Where are the remaining covered bridges concentrated? Use the CD-ROM to allow students to answer the question.
- Talk about the recent losses of covered bridges, including the Cedar Covered Bridge at Winterset, IA.

Activity 1 – Bridge Hunt

- For middle school students, have them break up into groups of three or four students, depending on class size. Tell them that they are going to go on a bridge hunt. Students are to track the covered bridges nearest to their location. Have the students research the bridges each group is interested in. Then have the groups give a PowerPoint presentation including pictures and interesting facts about their bridge. If PowerPoint is not available, groups can make a poster or display of some type using the relevant information.
- Secondary students could also do this activity. Furthermore, secondary students can also use this lesson in conjunction with the Restoration of Covered Bridges to design a restoration plan on a particular covered bridge near their area. They can do this in groups by researching which covered bridges are in their area, which ones need restoration, and so on. If there are any in their area that need to be restored in the near future, have them design a restoration plan for that bridge. If there are none, choose a bridge that has previously been restored. Have the students look at the conditions this bridge was in by examining what the engineers did to restore that bridge. Then they can develop their own plan and present it to the class.

Unit Ten: Restoring a Covered Bridge	
Lesson One: Historic Preservation and Historic Preservation Careers	**Grade Level: 5-12**

Learner Objectives

Students will be able to define historic preservation. Students will be able to identify the rationale for historic preservation. Students will be able to identify careers and their roles within the historic preservation profession.

Common Core Standards

- ♦ Reading Standards for Informational Text:
  - *RI.K-12.7* – Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. (Activities 2)
- ♦ Writing Standards:
  - *W.4-5.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 2)
- ♦ Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects:
  - *WHST.6-12.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 2)
  - *WHST.6-12.3* – Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences. (Activity 2)
  - *WHST.6-12.4* – Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Activity 2)
  - *WHST.6-12.7* – Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation. (Activity 2)
  - *WHST.6-12.8* – Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism. (Activity 2)
- ♦ Speaking and Listening Standards:
  - *SL.K-12.1* – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (Activities 1 and 3)

Duration

All grades – two 45-minute class periods

Materials

- ✓ Covered Bridges CD-ROM
- ✓ Internet access
- ✓ Encyclopedias

Teacher's Notes & Discussion

- Ask: Why do you think covered bridges are still around today? Write the responses on the board. Lead the discussion to historic preservation – many of the responses will probably be related to the reasons that people want to preserve the past. Tell the students that preserving a covered bridge is considered historic preservation and that historic preservation encompasses many things, such as historic sites, buildings, and archeological sites.
- Discuss with the students the idea that much of our past is represented by the architecture and items left behind by our ancestors and these things are keys to understanding our past and even our future. Without historic preservation, much of this knowledge would be lost.
- Ask the students to write on a piece of paper three items that they have kept from their past and why they have kept them. After sharing an item that you have saved, ask them each to share one item with the group and make a list on the board of the "whys." (There will probably be some commonalities.) Discuss how many of their reasons are the same reasons that spurred the U.S. Congress to pass The National Historic Preservation Act (NHPA) of 1966. This act was passed as an effort to provide national leadership for historic preservation in the United States. Under this act, national and state agencies partner to ensure that historically and prehistorically significant sites are preserved for future generation. Prior to this act, many sites were destroyed as new buildings, roads, railroads, bridges, etc. were constructed and now they have protection. Another aspect of this law was the creation of the National Register of Historic Places. If a given site is considered significant, after documentation, it is placed on the National Register. Sites placed on the National Register include historical districts, buildings, structures, archeological sites, or objects that are considered significant in American history, architecture, archeology, engineering, or culture. Covered bridges are often placed on the National Register. Ask the students why they think covered bridges are included. Give examples from your community of sites from the National Register of Historic Places (see National Register website listed in Sources below). This could be extended by taking a field trip to see some of the sites.
- Ask: Who do you think is involved in historic preservation? Write their ideas on the board. Discuss how historic preservation involves people of different professions such as historians, architects, landscape architects, draftsmen, engineers, and people in trade such as cabinetmakers, carpenters, plumbers, electricians, etc.

Activity 1 – Profession Research

- Assign each student, or group of students, a profession to research. Have them use the internet and any other resource available to them to write a few paragraphs about the profession and how it might be involved in historic preservation. (If working with the upper grade levels, the National Preservation Act and National Register of Historic Places could be researched, also.) Have them present their findings to the class. Tell the class that over the next few lessons that they will be discovering how several of these professions join together to restore a covered bridge.
- Review the concept of historical preservation and the role that it plays in the restoration of a covered bridge.

Activity 2 – Oral Report

- For Homework: Have the students ask two or three adults about two objects they have saved from their past and why. Discuss their findings the next days and compare the adults' reasons for saving the past to the students' reasons.

Sources:
www.cr.nps.gov/nr/research/nris/htm- National Register of Historic Places listings by state, county, or city can be located at this site.

Unit Ten: Restoring a Covered Bridge	
Lesson Two: Restoration or Rehabilitation?	**Grade Level: 5-12**
Learner Objectives	
Students will be able to identify the differences between restoration and rehabilitation. The students will be able to identify whether restoration or rehabilitation should be used in historic preservation of a covered bridge by applying criteria.	
Common Core and National Education Standards	
♦ Writing Standards: o *W.4-5.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 1) ♦ Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects: o *WHST.6-12.2* – Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content. (Activity 1) ♦ Speaking and Listening Standards: o *SL.K-12.1* – Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively. (Activity 1) ♦ Social Studies: o *Geography* ▪ *NSS-G.K-12.5* – Environment and Society – Students should understand the changes that occur in the meaning, use, distribution, and importance of resources. (Activity 1)	
Duration	
All grades – one 45-minute class period	
Materials	
✓ Restoration/Rehabilitation Worksheet	

Teacher's Notes & Discussion

- Tell the students that when a covered bridge is being examined for possible preservation there are two options: restore the bridge or rehabilitate the bridge. Write restoration and rehabilitation on the board for them in chart form adding the criteria as it is discussed. Ask the students to copy the chart from the board as it is created.
- Tell the students that restoration of a bridge or a building means to return it to its original form and appearance as closely as possible. Original materials, which are also known as the "historic fabric" of the bridge, are reused if possible. The end product looks very nearly the same as the original. Restoration is often the most expensive option and is used if funding is ample and it is possible to restrict the traffic load on the bridge.
- Tell the students that rehabilitation of a bridge or building means to preserve as much as possible of the original materials and features but allow for modern use. Examples of rehabilitation would be to reinforce wooden beams with steel beams to allow heavier traffic flow on a bridge or replacing timber members of a bridge with new ones. Rehabilitation is often used if funding is limited and if the bridge will carry a heavy traffic load.
- The chart on the board should look as such:

Restoration	Rehabilitation
Return to original form/look (hard to tell from original)	**Return to original look but with some modern materials or adjustments**
Reuse and repair original materials ("historic fabric")	**Reuse some original materials but often replace with modern materials instead**
Need ample funding (expensive)	**Limited funding available (less expensive)**
Possible to restrict traffic load (usually on roads used by few people)	**Can withstand heavier traffic load (usually on roads used by more people)**

- Ask the students to decide using their criteria chart whether the following examples illustrate the need for either restoration or rehabilitation or if they have already been rehabilitated or restored.
- This covered bridge is located on a small, rural road, most of its original members ("historic fabric") are in good condition and there will be an ample amount of funding. What would you do: restore or rehabilitate? (Restore)
- You see a covered bridge and you notice that underneath it are steel beams, the decking is covered in asphalt, and inside there are some new wooden beams along with the old ones. Do you think it has been restored or rehabilitated? (Rehabilitated)
- This bridge is located in an area that gets a lot of traffic, there is not a lot of money available to preserve it, and it has already had some of its original wooden members or "historic fabric" replaced. What would you do: restore or rehabilitate? (Rehabilitate)
- You see workers at a covered bridge earlier in the year along a country road and you go back 6 months later. You notice that on the inside all the "historic fabric" or wood members are all there and underneath the bridge it is all made of wood. Do you think it has been restored or rehabilitated? (Restored)
- Model the first example for them using the criteria table. Discuss the rest of the examples using the criteria with them.
- For practice: Give out the handout with more restoration/rehabilitation examples.

Sources:
www.cr.nps.gov
This is the National Park Service site and is valuable as a background research tool for the teacher and for students.

www2.cr.nps.gov/e-rehab/
This site is an electronic class on the standards for rehabilitation and includes a quiz using historic structures; it can be used for research or older students can use it for further enrichment.

www2.cr.nps.gov/tps/standguide/overview/choose_treat.htm
This site encompasses the National Park Services standards and guidelines for restoration and rehabilitation. It is very useful for background research for teachers as well as students.

Restoration or Rehabilitation?

Decide whether the following would be restoration or rehabilitation, circle your choice, and explain your choice:

1. Several people in the community would like to see the Workman Covered Bridge preserved. It is located on a country road with light daily traffic, most of its historic fabric is in good shape, and they think they can get funding from several sources.

   RESTORATION OR REHABILITATION
   WHY?

2. A group of citizens in the town would like to see the Jones Covered Bridge preserved. It is located on the edge of town on a road that leads into the downtown area with fairly heavy daily traffic. It has been modified in the past with new decking and supported below with beams.

   RESTORATION OR REHABILITATION
   WHY?

3. You see a covered bridge while driving with your parents in the country, since you have been studying covered bridges, you ask them to stop so you can look at it. Your father tells you that it has been restored in the past few years. When you look at it, you notice that it has been repaired but there are many new beams inside that do not look anything like the original ones that are still in place and you notice that the floor is not wood either. You tell your father this is a ______________________

   RESTORATION OR REHABILITATION
   WHY?

<table>
<tr><th colspan="2">Unit Ten: Restoring a Covered Bridge</th></tr>
<tr><th>Lesson Three: To Preserve or Not Preserve?</th><th>Grade Level: 5-12</th></tr>
<tr><td colspan="2">Learner Objectives</td></tr>
<tr><td colspan="2">Students will be able to identify sources for funding preservation of covered bridges. Students will be able to identify and support arguments for or against preservation.</td></tr>
<tr><td colspan="2">Common Core and National Education Standards</td></tr>
<tr><td colspan="2">♦ Reading Standards for Informational Text:
o RI.K-12.7 – Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words. (Activity 1)
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<tr><td colspan="2">Duration</td></tr>
<tr><td colspan="2">All grades – one 45 minute class period</td></tr>
<tr><td colspan="2">Materials</td></tr>
<tr><td colspan="2">✓ Fletcher Bridge video (from Covered Bridges CD-ROM)
✓ Covered Bridges CD-ROM
✓ To Preserve or Not Preserve handout
✓ Funding law handout</td></tr>
</table>

Teacher's Notes & Discussion

- Tell the students you will be using the Fletcher Covered Bridge in Harrison County, WV, as a model to explain the process of preservation of a covered bridge. (Other bridges, closer to the students' geographical area, could also be used with these lessons with some adaptation and research.) The CD-ROM could be used to locate the bridge prior to beginning the lessons.
- The Fletcher Bridge is located along a rural road in Harrison County, WV. It was built in 1891 using multiple Kingpost trusses and sandstone abutments at a cost of $1,372.46. It was placed on the National Register in 1981. Today, since the straightening of the road, it has

been bypassed by most traffic and serves as transportation across Ten Mile Creek for one family. It is being restored at an estimated cost of $270,000.

- Ask the students if they have any idea where the funding for preservation of covered bridges comes from. Tell them that the Federal Highway Administration (FHWA) has a National Historic Covered Bridge Preservation Program (NHCBP) to provide funding to assist the states with their efforts to preserve historic covered bridges that are eligible or are on the National Register. The states request money to preserve the bridges and an amount is awarded, usually not the full amount, and the states then provide matching funds to complete the project. (See FHWA website in Sources below, and NHCBP funding law handout.) Other sources of funding may be available from private individuals, corporations, trusts, non-profit organizations, other government programs etc. (As an extension, have the students research possible sources of funding.)
- Show the *Fletcher Bridge* video. This video may be reused or available for viewing as students complete the next lessons.
- After watching the video, ask the students if they think everyone in the community and those involved in possibly funding the bridge wanted to preserve it. Discuss how often there are opposing views when it comes to preservation. Sometimes people feel that it is an inefficient use of money and want to move ahead into the future, replacing them with more modern structures, while others feel that preserving the past is just as important as moving forward. This process of debating the pros and cons of preservations is often the first step in restoring a covered bridge.
- Ask the students to brainstorm about reasons for preserving the Fletcher Bridge versus not preserving the bridge, using the To Preserve of Not Preserve handout. Lead them to ideas of cost, number of people served, saving the past, tourism, etc.

Activity 1 – Discussion and Video

- After brainstorming, ask the students to pick a position- for or against preservation of the Fletcher Covered Bridge.
    - Option One: Students should write a paragraph supporting their position. They may use the internet to research their position.

    - Option Two: Set up a debate between those for preservation and those against preservation of the Fletcher Covered Bridge.

Sources:
www.fhwa.dot.gov/bridge/covered.htm
This is the Federal Highway Administration’s page for the National Historic Covered Bridge Preservation program. It contains information as to how the program works as well as listing the funds allocated for specific bridges and information as to the scope of work for the bridges. (If working with older students this is an excellent research site.)

To Preserve or Not Preserve?

Background Information:
The Fletcher Bridge is located along a rural road in Harrison County, WV. It was built in 1891 using multiple Kingpost trusses and sandstone abutments at a cost of $1,372.46. It was placed on the National Register in 1981. Today, since the straightening of the road, it has been bypassed by most traffic and serves as transportation across Ten Mile Creek for one family. Estimated cost of restoration is $270,000.

<u>Brainstorming List</u>

List all ideas during the class brainstorming session:

To Preserve	Not Preserve

After brainstorming session, decide which position you would take and why.

The Law Providing the Funding for Covered Bridge Preservation

SEC. 9003. RESTORATIONS TO GENERAL PROVISIONS SUBTITLE.

(a) IN GENERAL.- Subtitle B of title I of the Transportation Equity Act for the 21st Century is amended by adding at the end the following:

SEC. 1224. NATIONAL HISTORIC COVERED BRIDGE PRESERVATION.

(a) HISTORIC COVERED BRIDGE DEFINED. - In this section, the term 'historic covered bridge' means a covered bridge that is listed or eligible for listing on the National Register of Historic Places.

(b) HISTORIC COVERED BRIDGE PRESERVATION- Subject to the availability of appropriations under subsection (d), the Secretary shall-
- (1) collect and disseminate information concerning historic covered bridges;
- (2) foster educational programs relating to the history and construction techniques of historic covered bridges;
- (3) conduct research on the history of historic covered bridges; and
- (4) conduct research, and study techniques, on protecting historic covered bridges from rot, fire, natural disasters, or weight-related damage.

(c) DIRECT FEDERAL ASSISTANCE-
- (1) IN GENERAL- Subject to the availability of appropriations, the Secretary shall make a grant to a State that submits an application to the Secretary that demonstrates a need for assistance in carrying out one or more historic covered bridge projects described in paragraph (2).
- (2) TYPES OF PROJECT- A grant under paragraph (1) may be made for a project-
  - (A) to rehabilitate or repair a historic covered bridge

    And
  - (B) to preserve a historic covered bridge, including through
    - (i) installation of a fire protection system, including a fireproofing or fire detection system and sprinklers;
    - (ii) installation of a system to prevent vandalism and arson; or
    - (iii) relocation of a bridge to a preservation site.
- (3) AUTHENTICITY- A grant under paragraph (1) may be made for a project only if-
  - (A) to the maximum extent practicable, the project
    - (i) is carried out in the most historically appropriate manner; and
    - (ii) preserves the existing structure of the historic covered bridge; and
  - (B) the project provides for the replacement of wooden components with wooden components, unless the use of wood is impracticable for safety reasons.
- (4)FEDERAL SHARE- The Federal share of the cost of a project carried out with a grant under this subsection shall be 80 percent.

(d) FUNDING- There is authorized to be appropriated to carry out this section $10,000,000 for each of fiscal years 1999 through 2003. Such funds shall remain available until expended.

ANNOTATED BIBLIOGRAPHY FOR REFERENCE MATERIALS

KEY TO ANNOTATIONS

The reference sources contained in this bibliography have been annotated according to the types of information that they may supply for the covered bridge educational guide. The sources will be assigned one or more of the following classifications:

AUDIO-VISUAL: audio and visual materials that relate to covered bridges or any of the other annotation topics, which may potentially be used or adapted for classroom use.

BUILDERS: sources that may provide biographical and other information about notable covered bridge designers and builders, including those in the past, more contemporary builders, and specialists in restoration and rehabilitation.

CHILDREN: sources, written with a younger audience in mind, that may provide information about covered bridges, bridge design, and scientific or mathematical principles related to bridge design or construction.

CIVIL WAR: sources that may provide notable events that occurred on or near covered bridges during the Civil War.

CONSTRUCTION: sources that may provide information about the methods and equipment used to construct covered bridges.

DESIGN INFORMATION: sources that may provide information about the design process for covered bridges, particularly during the 19th century. (These sources may also provide information on scientific principles, engineering principles, and design calculations.)

ENGINEERING DRAWINGS: sources that may provide actual or reconstituted design and constructions drawings, including patent drawings, for covered bridges.

GENERAL HISTORY: sources that may provide actual or reconstituted design and construction drawings, including patent drawings for covered bridges.

INVENTORY: sources that may provide locations and descriptions of existing covered bridges in the United States.

MISCELLANEOUS: sources that may contain information related to covered bridges but that cannot easily be assigned to any of the other annotation classifications.

PICTURES: sources that may provide photographs, sketches, paintings, and other depictions of former and existing covered bridges in the United States.

RESTORATION: sources that may provide information about methods used to restore and rehabilitate covered bridges.

SOCIETIES: organizations, professional societies, and other groups that may provide useful information on covered bridge history, design, construction, or locations.

TIMBER AND WOOD: sources that may provide information about species of wood, range of growth for the respective trees, and physical and structural characteristics of wood and timber used to construct covered bridges.

TRANSPORTATION: sources that may provide information about changes in transportation and engineering methods that affected covered bridges.

TRUSSES: sources that may provide specific information about the types of trusses used in designing and constructing covered bridges.

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